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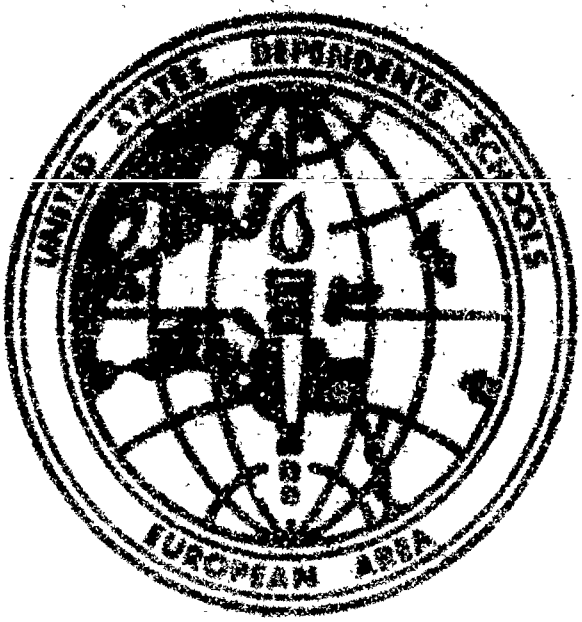
ABSTRACT

The curriculum guide is designed to provide high school students with realistic training in electricity/electronics theory and practice and to prepare them for entry into an occupation or continuing postsecondary education. The learning modules are grouped into three areas: electrical technology, radio-television technology, and industrial electronics. All modules in the outline are keyed to Electronic Aids, Inc. materials programs and equipment. Each unit plan consists of a description of the area under consideration, estimated hours of instruction, behavioral objectives, a module outline, a list of useful curriculum materials and resources, laboratory activities, and laboratory materials. The electricity/electronics curriculum covers the following topics: consumer electricity, elements of electricity, electrical wiring and equipment skills, principles of electricity, lighting and alarm installation skills, electro-mechanical control systems, elements of fluid control systems, motor services skills, motor control skills, elements of electronics, basic electricity/electronics skills, principles of electronics, transistor fundamentals, transistor applications, transistor and logic skills, office machine repair skills, fundamentals of AM receivers, AM receiver skills, fundamentals of FM receivers, FM receiver skills, principles of television, integrated circuit design, and logic circuit design. The document concludes with a suggested facilities layout of an electronics/electricity laboratory and an equipment list. (BP)

Career Education Guide

ELECTRICITY/ELECTRONICS



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EDUCATION

Career Education - Electricity/Electronics

This Career Education guide is an official publication of the Directorate, United States Dependents Schools, European Area. It is designed to serve as a curriculum guide for the electricity/electronics cluster. The principal will establish adequate accountability procedures for all copies issued.

FOR THE DIRECTOR:

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FOREWORD

The career area of Electricity/Electronics is an essential part of the fiber of the modern technological society. Our communication systems, our factories, our transportation systems, our education systems, and even our homes are dependent on the use of electricity.

Job possibilities in the field are excellent but will increasingly demand higher level skills as the technology advances. Therefore, the serious student in the field should understand that he will need to continuously upgrade his knowledge and skills throughout his career life to keep abreast of the technology.

It is not recommended that every school undertake a full electricity/electronics program as outlined in this program guide. Because the more specialized programs require considerable teacher experience in the field, some schools may lack this kind of in-house expertise which is essential on the electronics side of the program. Where possible, advanced students should be transferred to a regional skills center or to one of the larger schools which has an advanced program so that the student can have the benefit of both greater staff experience and broader peer education stimulation.

This outline utilizes programs and equipment, much of which is already available in USDESEA, so that full and economic use of existing materials can be made. The program utilizes class activities for development of broad concepts and principles but quickly moves the student into laboratory activities and/or skills training practicums for hands-on work.

All modules in this outline are keyed to the Electronic Aids, Inc. (EA) materials, programs, and equipment. Consequently, all text and unit numbers refer to EA publications and materials, which the company supplied to TAI so that a program could be developed around USDESEA's current equipment and learning package list.

The program modules in this guide have been grouped into three broad areas - electrical technology, radio-television technology, and industrial electronics. In addition, sub-branches of these are to be found in the career cluster wall charts of the business cluster and the computer technology cluster. In these sub-branches, special applications to the fields of business machines and computer mechanics are charted.

Effective laboratory spaces for this cluster may be organized in numerous ways and in various sizes. However, the educator responsible for space development may wish to use the attached laboratory schematic as a guide. It was developed to give optimum relationships between probable space available and the various functions to be served. Obviously variations will be required at every site, both in size and scope.

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CONTENTS

ILLUSTRATIONS

PURPOSE OF THE GUIDE

This Career Opportunity Guide is prepared to assist in implementing a suggested learning system designed to provide the student with entry-level skills to numerous jobs in the broad field of Electricity/Electronics. The system also provides a substantial base for the student who decides to extend his career potential by continuing professional study at a community college, a four-year college, or technical school.

This guide should also suggest to instructors of differing disciplines possible applications of the modules described to satisfy needs of students in their own areas. Cooperation among instructors and administrators and individual imagination are the only limiting factors.

The guide describes each of the elements in the system which will assist instructors and administrators in implementing the career program. It is not a study guide but includes enough information for the prospective instructor to plan his course with his own special requirements and preferences in mind.

In addition to the program outline, there are lists of references, equipment, and materials as well as distributor sources.

DESCRIPTION OF LEARNING SYSTEM

The Electricity/Electronics Career Cluster is a two-year program which considers the needs, capabilities, background, and interests of each student enrolled. Instruction must, therefore, be individualized to the greatest extent possible considering the time and resources available. The routine classroom lecture should be reduced in its role as the primary teaching method. It should be used merely to introduce broad areas and should permit the students to discover details in small groups or on their own. Individualized learning depends heavily upon self-instructional materials, audio-visual learning aids, and student tutors.

To operate successfully, the learning environment must be free and open, but well ordered and managed with specific objectives in mind. Given such an environment, each student enters at his or her own level of achievement and moves along at his or her own rate of speed. A contract system may be used to monitor and improve upon the achievement rate. Progress is measured against individual performance rather than against that of the class as a whole. This allows students of all ability ranges to be in the same class. The high achievers can move ahead freely without being hampered by their slower classmates and can explore enrichment quests on their ow... On the other hand, low achievers, already discouraged by repeated failures, are not threatened by further failure. They start wherever they are academically and attitudinally and immediately receive positive experiences which encourage them to progress.

Students need not accomplish modules in the same order. The instructor may prescribe or may negotiate with the student a selection of modules to accomplish a particular student's career goal, depending upon the student's interests and achievement level. Evaluation through pretesting may indicate that a student can skip over an entire module or part of a module.

The role of instructor becomes one of learning facilitator. The instructor prescribes the framework and procedures whereby the learner can accomplish the terminal performance objectives which will be consistent with the entry-level requirements for the career goal.

The wide cross section of learning modules suggested in this career cluster is designed to provide as great a selection of job entry-level skills as appears practical considering resource and time restraints. Individual requirements differ from school to school; therefore, the design of this learning system provides for the selection of modules to satisfy particular needs.

In addition to the program outline, there are lists of references appended. Equipment and materials lists are to be found in the texts for each module which are available from Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093.

SUGGESTIONS FOR ORGANIZATION OF INSTRUCTION

In order to facilitate the student's completion of performance objectives in the learning system and to provide for necessary management, the following list of instructor objectives is recommended:

1. Acquaint students with class procedures.

2. Provide students with assistance in module sequencing with career goals in mind.

3. Establish small groups for study and activity purposes.

4. Encourage peer tutoring.

5. Distribute all module objectives to students and assist in relating these objectives to entry-level skill requirements.

6. Assist students in completing performance objectives by providing demonstrations of skills and concepts for each module of instruction.

7. Develop individual contracts with students defining related learning activities.

8. Provide opportunities where students can observe the activities of individuals in a variety of jobs in the career field and assist students to relate the educational goals of the learning system to the development of entry-level skills.

9. Construct and evaluate pre-tests and post-tests for each module.

10. Construct reading assignment and audio-visual review lists for each module.

11. Provide trays, drawers, or learning stations with the appropriate materials and instructions to complete laboratory activities.

12. Maintain an attractive and stimulating working environment and encourage students to display their projects or materials collected from related fields of study.

13. Invite guest speakers to discuss appropriate topics related to the field of study.

14. Encourage and actively recruit students of different disciplines to work on modules in this career cluster which may have applications for their field.

15. Encourage students working in this career cluster to examine objectives of modules in other areas with a view toward possible application to their goals.

ELECTRICITY/ELECTRONICS CAREER CLUSTER CHARTS

The curriculum of the Electricity/Electronics Career Cluster is designed to prepare students for entry into one of a broad selection of occupations or continuing post-secondary education.

The relationship of the courses or modules to preparation for entry into particular jobs has been shown on the wall charts labeled:

- Electricity/Electronics Career Cluster

- Preparation Requirements for Electricity/Electronics Careers

COURSE MODULES AND LENGTH OF INSTRUCTION

This career cluster as outlined allows for a variety of career programs ranging from less than a semester to two years of training. Since the curriculum calls for individualized learning and students work at different rates of performance, it is difficult to specify exact times for accomplishment. The following list, therefore, shows an approximation of the average student time it takes to accomplish the performance objectives and is useful only as a general reference for planning.

Most of the theory modules require or would be strengthened by concurrent work in a skill module. Thus, the laboratory activity time may be adjusted according to instructor preference.

Module	Estimated Learning Time in Hours
Consumer Electricity (Optional Introductory Module)	45
Elements of Electricity	90
Electrical Wiring and Equipment Skills	90
Principles of Electricity	180
Lighting and Alarm Installation Skills	90
Electro-Mechanical Control Systems	200
Elements of Fluid Control Systems	70
Motor Services Skills	70
Motor Control Skills	70
Elements of Electronics	90
Basic Electricity/Electronics Skills	90
Principles of Electronics	180
Transistor Fundamentals	135
Transistor Applications	180
Transistor and Logic Skills	40
Office Machine Repair Skills	None Specified
Fundamentals of AM Receivers	135
AM Receiver Skills	45
Fundamentals of FM Receivers	135
FM Receiver Skills	45
Principles of Television	50
Integrated Circuit Design	75
Logic Circuit Design	75

SKILL TRAINER MODULES

Most of the modules either require or will be strengthened by concurrent enrollment in one or more skill modules. Each of these modules uses specific training equipment geared to the program and supplied by the same publisher - Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093. Equipment and materials lists are to be found in the teacher's manual accompanying each EA unit.

The learning times cited are only general guides for the teacher. By selecting and rejecting certain units in a given module, it may be fitted very closely to a given student's program and thus may vary widely from the suggested learning time noted.

ELEMENTS OF ELECTRICITY

DESCRIPTION

Elements of Electricity (EA unit A1000) ... provides the student with an overview of electricity as the conversion of energy. It is intended as an introductory module for persons having a very limited background in the concepts of energy conversion. The changing of energy from one form to another and the application of various forms of energy are covered in the subject matter.

LEARNING TIME

Hours: 90

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Identify the transducers of light, heat, sound, and motion.
2. Identify a basic circuit for motor control.
3. Draw the circuit for a battery charger.
4. Draw a circuit, using switches, to indicate a logic AND/OR.
5. Draw or identify a circuit for temperature control of a motor.
6. Describe or identify the difference between a voltmeter and milliammeter.
7. Draw or identify a circuit for producing sound from electricity.

Acceptable achievement will be determined by successful accomplishment of laboratory exercises and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Changing Energy Forms
   1. electrical forms of energy
      a. light
      b. magnetism
      c. mechanical motion

d. chemical action

e. heat

f. sound

2. energy forms producing electricity

a. light

b. magnetism

c. mechanical action

d. chemical

B. Applying Forms of Energy

1. light

a. controlling

b. measuring

2. solar cells

3. measuring devices

a. ammeters

b. voltmeters

4. motors

5. motor circuit alarm systems

6. batteries

a. charging

b. make-up

7. heat and electricity

a. regulating electricity

b. measuring by electricity

c. alarm system

d. motor control system

8. sound and electricity

9. computer circuits and their applications

a. OR circuit

b. AND circuit

CURRICULUM MATERIALS

Concepts of Electricity, P92 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Concepts of Electricity, P92-2 (EA)

Standard Tests for Concepts of Electricity, P92-9 (EA)

Instructional Manual for Commercial and Industrial Electrical Wiring Practices, P57. (EA)

LABORATORY ACTIVITIES

1. Demonstrate transducer qualities of light bulb and dry cell
2. Demonstrate transducer qualities of a solar cell
3. Demonstrate qualities of magnetism
4. Produce electrical current with magnetism
5. Produce mechanical motion with electrical and magnetic energy
6. Produce electricity with mechanical motion in a magnetic field
7. Make a wet cell and observe its action
8. Demonstrate electrolysis
9. Produce heat with electricity
10. Produce sound with electricity
11. Control light output by reducing electrical flow
12. Measure light with a solar cell
13. Arrange solar cell in a manner to increase voltage
14. Demonstrate motor actions in producing energy
15. Use metering devices ammeter, voltmeter
16. Build a motor alarm circuit
17. Recharge a battery and observe process
18. Construct chemical cells using different foods
19. Demonstrate characteristics of a thermistor
20. Construct a simple electric thermometer
21. Construct a heat operated alarm circuit
22. Control actions of a motor with a thermistor
23. Demonstrate characteristics of sound in relation to electricity
24. Demonstrate characteristics of simple logic circuits

LABORATORY MATERIALS

All of these activities use the conceptual trainer, model A1000 (EA). See the Teachers Guide for Concepts of Electricity, P92-2 (EA), pages 14-15 for a parts list.

Enrichment activities are provided with the skill trainer PR50. See the Instruction Manual for Commercial and Industrial Electrical Wiring Practices (EA) P57, pages 15-16 for parts and tool lists.

ELECTRICAL WIRING AND EQUIPMENT SKILLS

DESCRIPTION

Electrical Wiring and Equipment Skills (EA unit PR50) ... acquaints students with techniques of wiring and use of equipment and hardware.

LEARNING TIME

Hours: 90

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instructional Manual for Commercial and Industrial Electrical Wiring Practices, P57 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Introduction to tools and equipment
   a. identification and use of hand tools
   b. use of electrical tape
   c. power tools
   d. safety
   e. wire, cable, and cord
   f. soldering irons and guns
   g. drills and bits
   h. switches
   i. batteries and transformers
   j. electrical blueprints and symbols

k. use of steel fish tape

l. fuses

2. Identification of electrical hardware

3. Splicing wire and use of insulation

   a. pigtail splice

   b. tee-tap splice

   c. Western Union splice

   d. soldering a splice

   e. putting tape (insulation) on a splice

   f. wire nuts used for splicing and insulation

4. Introduction to house wiring

5. House wiring circuits and use of electrical materials

   a. ceiling lamp wired to wall switch using Romex cable

   b. lamp connected to single-pole switch using BX cable

   c. two three-way switches controlling one lamp

   d. fuse block connected to lamp and three-way switches

   e. two receptacles wired to fuse block using Romex cable

   f. one lamp controlled by wall switch - one lamp controlled by pull-chain switch

6. Obtain light from electricity

   a. attach lamp socket and plug to lamp cord using proper knot and connections

   b. build a circuit tester with neon lamp

   c. connect four lamps in parallel

   d. connect four lamps in series

   e. connect two lamps in parallel and then in series

   f. build a table lamp

7. Obtain sound from electricity

   a. connect one bell and one pushbutton switch to a transformer

   b. ring one bell from either one of two pushbutton switches

   c. control one bell and one buzzer with one pushbutton switch

   d. control one bell and one buzzer with two pushbutton switches

8. Obtain heat from electricity - power consumption

   a. building and using a continuity tester

   b. testing continuity of switches, cables, fuses, and circuits

c. testing heater elements

d. determine how much current an electrical device uses

e. determine the cost of electricity

9. Remote control

   a. building a remote control system - high-voltage circuit controlled by a low-voltage circuit

10. Fluorescent lighting

    a. electric lighting circuit using fluorescent components

11. Thermostat controls

    a. building a system that uses a thermostat

PRINCIPLES OF ELECTRICITY

DESCRIPTION

Principles of Electricity (EA unit A500) ... introduces the student to basic circuits used in appliances, lighting, relay, and motor control. Basic electric instruments are also examined. Mathematical computations are minimized and high motivation is achieved through early hands-on laboratory activities. Related skill training covering commercial and residential wiring is provided by exercises using the lighting and alarm skill trainer.

LEARNING TIME

Hours: 180

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Identify by symbol and use the electrical components used in the course.
2. Solve problems in DC circuits.
3. Identify or draw circuits related to basic motor controls.
4. Test and troubleshoot basic control circuits.
5. Compute power consumption problems in KWH.
6. Describe the use and operation of circuit protection devices, such as fuses and breakers.
7. Solve problems related to step-up and step-down of voltage/current using a transformer.
8. Describe the operation of the solenoid.
9. Describe the construction of the dry and wet cell.
10. Draw the circuit for a battery charger.
11. Draw and describe the construction of meter types included in the course.
12. Calculate the values of meter shunts/multipliers.

Acceptable achievement will be determined by successful accomplishment of laboratory activities and skill trainer exercises and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Electrical Components and Circuits
   1. conductors and insulators
   2. electrical components
      a. switches
      b. lamps
      c. heaters
   3. controllers
      a. thermostats
      b. circuit breakers
      c. relays
      d. fuses
   4. electrically produced linear motion
      a. solenoids
      b. relays
   5. electrically produced rotating motion

B. Electrical Measurements
   1. flow
   2. pressure
   3. resistance
   4. circuit tests
   5. process of measuring electrical energy

C. Electrical Paths
   1. characteristics of electrical parts in series
   2. characteristics of electrical parts in parallel
   3. combination circuits

D. Heat and Resistance in Metals
   1. conditions affecting resistance of metals
   2. resistance wire - heaters
   3. size of wire and heating characteristics
   4. heat controlled circuit protectors

E. Controlling Voltage
   1. rheostats
   2. transformers
      a. types
      b. effects on current
      c. power rating
      d. testing

F. Electrically Induced Mechanical Linear Motion
   1. solenoid characteristics
   2. relay characteristics
   3. relay motor controls

G. Electrically Induced Mechanical Rotating Motion
   1. motor applications
   2. AC motors
   3. characteriscics of capacitors
   4. testing motor coils
   5. motor maintenance

H. Alternating Current and Direct Current
   1. sources of DC current and their characteristics
      a. dry cells
      b. wet cells
      c. recharging batteries
      d. DC from AC source
   2. generating AC electricity

I. Electrical Instruments and Their Characteristics
   1. operation of electrical meters
   2. types
      a. DC meter
      b. ohmmeter
      c. AC meters
   3. thermocouples

J. Purchasing Electricity
   1. measuring devices
   2. figuring cost
   3. costs of running appliances

K. Electrical Precautions
   1. importance of grounding
   2. dangers of electrical shock

CURRICULUM MATERIALS

Basic Electrical Practices, P52T (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Experiments in Electricity, P91 (EA)

Teachers Guide for Experiments in Electricity, P91-2 (EA)

Students Workbook for Experiments in Electricity, P91-6 (EA)

Standard Tests for Experiments in Electricity, P91-9 (EA)

Instructional Manual for Lighting - Alarm Systems, P56 (EA)

LABORATORY ACTIVITIES

1. Demonstrate use of electrical metering devices
   a. AC ammeter
   b. DC ammeter
   c. AC voltmeter
   d. DC voltmeter
   e. measuring resistance with a VOM
   f. testing continuity
   g. measuring power with a VOM
2. Test and demonstrate characteristics of series circuits
3. Demonstrate characteristics of parallel circuits
4. Demonstrate characteristics of series-parallel circuits
5. Measure heat and resistance in conductors
6. Test and demonstrate characteristics of magnetism-coils and transformers
7. Demonstrate characteristics of capacitors in:
   a. DC circuits
   b. AC circuits

8. Demonstrate characteristics of sensing and protective devices
   a. thermostat
   b. thermistor
   c. simple pyrometer
   d. overload protection
9. Demonstrate use for the silicon rectifier
10. Demonstrate characteristics of control circuits

Enrichment activities are provided with the skill trainer PR55. This module presents 55 different learning tasks dealing with commercial and residential wiring. Sign display wiring, burglar and fire detection alarms, and fixture and receptacle planning are among the subjects covered.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

Skill trainer PR55 with accompanying materials is required for enrichment activities.

LIGHTING AND ALARM INSTALLATION SKILLS

DESCRIPTION

Lighting and Alarm Installation Skills (EA unit PR55) ... provides enrichment activities dealing with commercial and residential wiring, sign display wiring, burglar and fire detection alarms, and fixture and receptacle planning.

LEARNING TIME

Hours: 90

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instructional Manual for Lighting - Alarm Systems, P56 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Service entrance power wiring
   a. service entrance heads
   b. wire sizes and types
   c. grounding clamps and methods
2. Receptacle outlets
   a. receptacle wired to source, with ground wire
   b. receptacle wired in parallel with continuing electric line
   c. switch control receptacle
3. Fixtures and receptacles controlled by wall switches
   a. wall fixture and switch control
   b. ceiling fixture and switch control

c. combined receptacle, wall switch, and ceiling fixture

d. combined wall fixture, ceiling fixture, and switch

e. controlling wall and ceiling fixtures with wall switch

f. wall fixture controlled by three-way switches (power fed through switch box)

g. wall fixture controlled by three-way switches (power fed through fixture box)

h. wall fixture controlled by three-way switches (power fed through one switch box)

i. receptacle controlled by three-way switches (power fed through receptacle box)

j. two circuit duplex receptacles with one receptacle switch controlled

4. Low-voltage remote control wiring

   a. ceiling fixture controlled with three separate switches

   b. ceiling fixture, wall fixture, receptacle, each controlled with separate remote controlled switches

   c. ceiling fixture, wall fixture, receptacle, controlled with separate remote control switch and master control switch

5. Fluorescent and luminescent lighting

   a. fluorescent fixture controlled by wall switch

   b. fluorescent fixture controlled by wall key switch

   c. testing fluorescent fixture components (ballasts, starter)

   d. luminescent night lighting

6. Light dimmer control

   a. dimmer control of ceiling fixture

   b. dimmer control of ceiling fixture and wall fixture

   c. dimmer control of flood lighting (interior or exterior)

7. Heat controllers

   a. food conditioning with infrared heat lamps, controlled by wall switch

   b. variable heat control of infrared lamp using dimmer control

8. Display lighting - combination signs

   a. testing of low- and high-voltage transformers

   b. neon sign display lighting

   c. wiring a moving light display sign using variable stepper control

d. wiring a moving light display sign with group lighting control

e. wiring a moving light display sign providing reverse motion

f. moving light stepper control combined with neon sign display as terminal light

g. moving light random control with neon sign display continuously on

h. remote control of sign display lighting

i. dimmer control of sign display lighting

9. Switch and relay alarm

a. window or door alarm systems (using alarm key switch, microswitch, and transformers)

b. wiring a complex nonstopping alarm system with day and night control

c. taping of windows and doors for burglar alarms

d. testing window and door tapes and interlock switches

e. wiring burglar alarm systems and exterior flood lighting

f. wiring burglar alarm systems with interior and exterior flood lighting

g. testing relays and their control circuits

h. remote control of interior and exterior lighting for alarm purposes

i. wiring interdependent relay circuits

10. Fire detector device

a. fire detector, alarm only

b. fire detector, alarm and indicating light

c. electric door opener, protection and security

11. Fixture and receptacle planning

a. floor planning of residential areas (house and garage standard wiring)

b. floor planning of interior and exterior residential areas (two-story house - includes lighting for protection)

c. floor planning of electrical outlets for appliance applications (first floor and basement)

d. floor planning of industrial wiring for factories (includes alarm systems)

e. floor planning of residential area using remote control

f. floor planning of a ranch-type home for sequential lighting (no remote control)

ELECTRO-MECHANICAL CONTROL SYSTEMS

DESCRIPTION

Electro-mechanical Control Systems (EA unit A2000) ... provides the student with a broad view of the types of control circuits used in industry. The module is divided into the study of three principal types of controls: electrical-mechanical, transducers, and solid state circuits. Beginning with a simple switch controlling a motor, the module progresses to switches controlling relays that control motors; the use of indicator devices; the replacement of relays by solid state controllers; and the use of temperature, light, pressure, and liquid level transducers. The switching capability of solid state components is the concluding area of study.

LEARNING TIME

Hours: 200

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Draw or identify an overload control circuit for a motor which uses a thermal circuit breaker.
2. Draw or identify a three-wire motor control circuit.
3. Draw or identify a circuit for providing motor jogging.
4. Draw or identify a circuit which provides for motor reversing by means of a switch.
5. Draw or identify a bridge-type circuit for providing full wave DC output from an AC input.
6. Draw or identify a diac/triac control circuit for varying the speed of a motor.
7. Calculate the series resistor required for a Zener diode when the supply and Zener voltage as well as the current operating limits of the Zener are known.
8. Draw or identify a photo control circuit which uses a photoconductive cell and transistor for motor control.
9. Draw or identify a control circuit for indicating the liquid level in a tank.

10. Draw or identify a thermistor bridge circuit for the measurement of temperature change.

Acceptable achievement will be determined by successful accomplishment of laboratory activities and training skill exercises and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Electrical-mechanical Controls
   1. introduction
   2. types of control systems
      a. switches
      b. circuit breaker - relay protection
      c. pushbutton - relay
      d. two- and three-wire motor controls
      e. local/remote - start/stop
      f. full voltage - low voltage
   3. monitor systems
   4. jogging circuits
   5. motor direction circuits
   6. motor breaking and off circuits
   7. series starting - DC motors
   8. troubleshooting control circuits

B. Transducer Components
   1. DC power supply
   2. introduction to solid state devices - the diode
   3. diode as a rectifier; a simple go/no-go test for a diode
   4. solid state rectifier circuits
   5. bridge rectifier circuit
   6. power supply filters
   7. ripple output from rectifiers and filters
   8. voltage multipliers; voltage doubler circuits
   9. voltage divider
   10. Zener diode
   11. Zener regulator

12. introduction to the transistor
13. more about transistors; go/no-go transistor tester
14. Zener-transistor series regulator
15. silicon controlled rectifier
16. diac and triac controllers

C. Solid state Control Circuits
1. low voltage controls
2. silicon controlled rectifier circuits
3. diac/triac motor control system
4. solid state switching
   a. static switch
   b. interlocking motors
   c. dynamic breaking and speed control
   d. sequential starting
5. thermal controls
6. light-sensitive controls
   a. photo-electric
   b. light activated motor control
   c. light activated visual alarm
   d. delayed action control
   e. relay memory
   f. selection and counting devices
7. liquid level controls
8. troubleshooting
9. locating and correcting circuit problems

CURRICULUM MATERIALS

Industrial Control Systems, P93 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Industrial Control Systems, P93-2 (EA)

Standard Tests for Industrial Control Systems, P93-9 (EA)

Electric Motor Theory and Maintenance, P82 (EA)

LABORATORY ACTIVITIES

The text, Industrial Control Systems, provides for student-directed experiments to accompany each of the items listed in the outline.

Further enrichment activities about motor maintenance, including wiring connections, current measurement, testing, and trouble-shooting, are provided in skill trainer PR20.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

ELEMENTS OF FLUID CONTROL SYSTEMS

DESCRIPTION

Elements of Fluid Control Systems (EA unit A1500A) ... provides the student with an overall concept of some of the pneumatic control circuits used by industry. The operation of controller components such as valves, chambers, orifices, and cylinders is presented consecutively as the control circuit is closely examined. Of special interest is the presentation of pneumatic control logic, including AND, OR, NAND, NOR and memory circuits.

LEARNING TIME

Hours: 70

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Draw or identify a control circuit used in a punch press and activated by a three-way valve and single valve.
2. Draw or identify the use of a check valve for reverse control.
3. Draw or identify a control circuit which can be used on a pneumatic press for forming brittle materials.
4. Describe the operation of a fixed or variable orifice.
5. Describe the operation of a spring-return cylinder.
6. Develop a circuit for a pneumatic logic, two-input AND circuit.
7. Develop a circuit for a pneumatic logic, two-input OR circuit.
8. Develop a circuit for a pneumatic logic, three-input AND circuit.
9. Develop a circuit for a pneumatic logic, two-input NOR circuit.

Acceptable achievement will be determined by successful accomplishment of the laboratory activities and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Concept of Automated Production Assembly System

1. punch control systems
   a. three-way valve - single acting cylinder
   b. check valve - reverse flow
   c. orifice speed control
   d. flow control valve
   e. four-way valve - double acting cylinder
   f. quick exhaust valve
   g. remote actuation - four-way valve
2. automated function components
   a. forming - automatic air cylinder clamp
   b. stamping - adjustable work cylinder time delay
   c. air cylinder work clamp - time delay
   d. box filling - semiautomated circuit
   e. assembly - pneumatic machine
   f. hole punch press - one-shot actuated control
3. fluid power devices and components
   a. impact press with controlled retract stroke
   b. bleed actuation of a four-way valve
   c. forming press control circuit, automatic retract and bleeder operated four-way valve
   d. air operated water pressure booster pump
   e. part-number stamp, with automatic eject
   f. constant reciprocation pneumatic stamping press
   g. constant reciprocation stamping press with pneumatically coupled roll stock feed
   h. automatic box loading, closing and stapling, cam sequence control circuit
   i. pneumatic work clamp and drill-press feed and automatic retract
   j. assembly line two-man part-number stamping operation
   k. heat treating furnace, pneumatic loading mechanism
   l. pneumatic cylinder synchronization for press brake
   m. two-hand safety circuit for press operation

B. Pneumatic Computer Logic Circuits

1. two-input AND circuit
2. three-input AND (control) circuit
3. three-input AND (power) circuit
4. two-input OR circuit
5. memory circuit
6. two-input NAND circuit
7. two-input NOR circuit

CURRICULUM MATERIALS

Fluid Control Fundamentals, P86 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Fluid Control Fundamentals, P86-2 (EA)

Standard Tests for Fluid Control Fundamentals, P86-9 (EA)

LABORATORY ACTIVITIES

The text, Fluid Control Fundamentals, provides for student-directed experiments to accompany each of the items listed in the outline.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

MOTOR CONTROL SKILLS

DESCRIPTION

Motor Control Skills (EA unit PR40) ... provides enrichment activities in the wiring of control circuits with heavy duty controllers. Students solve problems which call for developing and testing circuit designs.

LEARNING TIME

Hours: 70

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instruction Manual for Industrial Motor Control, P83 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Manual starters
   a. full-voltage AC manual starters
2. Magnetic starters
   a. full-voltage AC magnetic starters with low-voltage protection
   b. full-voltage AC magnetic starters using two-wire control and having low-voltage release
   c. full-voltage AC magnetic starters with a control transformer for reduced-voltage control
   d. full-voltage AC magnetic combination starters

3. Overload relays

   a. overload relay protection of an AC motor

   b. two starters, each having individual start-stop stations with overload protection

   c. two-wire control with added control relay to provide low-voltage protection

4. Pushbutton stations and indicator lights

   a. multiple pushbutton stations operating a single starter

   b. start-stop station with an indicator ON light when running

   c. start-stop station with an indicator OFF light

   d. start-stop station with indicator ON light when running and indicator OFF light when stopped

   e. multiple starters operated from a single start-stop station

5. Jogging and motor reversing

   a. jogging with selector switch

   b. jogging with control relay

   c. jogging with roto-push selector pushbutton, stop button, and control relay

   d. three-phase reversing .

   e. pushbutton station wired for motor reversing without pushing stop button - low-voltage control

   f. pushbutton station with indicator light for direction of rotation

   g. selector switch to determine direction of motor travel

   h. limit switch to control direction and distance of motor travel

   i. reverse jogging with control relay

   j. forward and reverse jogging with a selector switch

6. Motor sequencing

   a. motor #2 starts to run for short time after motor #1 has stopped

   b. two motor starters operated from a single start-stop pushbutton station - time delay prevents them from starting together

   c. two starters arranged for conveyor system control

   d. starting any one of several motors causes an additional motor to start

7. Transistor relay control
    a. transistor relay control with roto pushbutton switch and timer
    b. low-voltage detection control with transistor relay
    c. photoconductive cell and heat transistor relay control
    d. limit switch control transistor relay
    e. liquid level probes control transistor relay
8. Liquid level float control
    a. float switch controls starter
    b. pressure switch controls starter with RUN-OFF-AUTO
9. Silicon control rectifier (SCR) controller
    a. SCR control of DC motor
    b. testing and servicing an SCR controller
    c. motor installation and care
10. Customer specifications - problems
    a. reversing motor control
    b. jogging and reversing
    c. sequential control
    d. two-motor control
    e. manual and automatic control
    f. lathe control
    g. fan control
    h. manual control of motors
    i. automatic control of motors
    j. automatic sequencing of motors
11. Panel design and layout
    a. three operating stations controlling a motor
    b. individual control of two motors
    c. pressure switch control
    d. two-motor control and timing
    e. three-motor control
    f. indicating lights and reversing
    g. incorporation of electronic control

h. conveyor control

i. pump control

j. automatic sequential operation of a lathe

12. Maintenance and troubleshooting tips

13. Grounding, shock hazard, and resuscitation

MOTOR SERVICES SKILLS

DESCRIPTION

Motor Services Skills (EA unit PR20A) ... provides enrichment activities and practice in motor maintenance, wiring connections, current measurement, testing, and troubleshooting.

LEARNING TIME

Hours: 70

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Electric Motor Theory and Maintenance, P82 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Wiring connections for a single-phase dual voltage motor
2. Wiring connections for a three-phase dual voltage motor
3. Wiring connections for a DC motor
4. Current and RPM measurements for single-phase, three-phase, and DC motors
5. Preliminary single-phase motor tests
6. Single-phase motor service
7. Three-phase motor service
8. DC motor service
9. Single-phase motors
   a. split phase
   b. capacitor start

c. permanent-split capacitor

d. repulsion start induction run

e. universal

f. shaded pole

g. single-phase troubleshooting

10. Three-phase motors

a. squirrel cage

b. wound rotor

c. three-phase to single-phase conversion

d. three-phase troubleshooting

ELEMENTS OF ELECTRONICS

DESCRIPTION*

Elements of Electronics (EA unit A1200) ... provides the inquiring student with a broad view of the field of electronics. The systems, subsystems, and transducers which comprise the basics of electronics are explored. Audio components, radio transmitters and receivers, telemetry, antennas, and light beam communication are systems closely examined. Electronic measuring devices are also studied.

LEARNING TIME

Hours: 90

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Define the parts of a basic system.
2. Draw the block diagrams for:
   a. high-fidelity system
   b. receiver
   c. transmitter
3. Identify the part symbols used in electronics.
4. Describe the operation of each subsystem used in the course.
5. Define the parts and use of components used in antennas.
6. Describe how information is transmitted through space
   a. using magnetic waves
   b. using light
7. Identify the controls of an oscilloscope and their use.

Acceptable achievement will be determined by successful accomplishment of the laboratory exercises and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Electronic Systems

1. sound reproduction
   a. record playback
   b. record player system test
   c. public address-music systems
2. high-fidelity components
   a. sound reproduction - enclosed and unenclosed
   b. modules functions and tests
3. amplitude modulation receivers
   a. what makes them work
   b. components
   c. building one
4. amplitude modulation transmitters
   a. what makes them work
   b. components
   c. building one
5. morse code telemetry
   a. building a transmitter and receiver
   b. morse code
   c. pulse measurement
   d. properties of radio waves
6. ansmitting radio waves
   a. UHF transmitter
   b. antennas
   c. radiation pattern
   d. polarization
   e. field strength
7. communicating by light
   a. transmission media and data
   b. system operation
   c. light waves

B. Electrical Amplification and Measurement

1. measuring current and voltage
    a. types of meters
    b. reading meters
2. vacuum tubes as amplifiers
    a. the triode
    b. amplifying voltage
3. operating an oscilloscope
    a. learning the controls
    b. measuring types of voltage
    c. sine wave analysis
    d. measuring gain

CURRICULUM MATERIALS

Concepts of Electronics, P11 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Concepts of Electronics, P11-2 (EA)

Standard Tests for Concepts of Electronics, P11-9 (EA)

LABORATORY ACTIVITIES

1. Demonstrate relationships that exist between voltage and amperage in an electrical circuit
2. Using a compass, determine the north and south poles of bar magnets
3. Determine the reaction of bar magnets when different poles face each other
4. Determine and sketch polarity lines using a bar magnet, iron filings, and a piece of paper
5. Connect an oscilloscope across the input of an amplifier and observe and draw the pattern
6. Connect an oscilloscope across the output of an amplifier and observe and draw the pattern

LABORATORY MATERIALS

power source: 1-1/2, 3, 4-1/2, and 6 volts

lamp, 6 volt, and lamp holder

ammeter, DC

permanent bar magnets

compass

iron filings

amplifier

oscilloscope

graph paper

BASIC ELECTRICITY/ELECTRONICS SKILLS

DESCRIPTION

Basic Electricity/Electronics Skills (EA unit PR100) ... is a basic tools skill module. Heavy emphasis is placed upon use of tools for electrical fabrication. Skill is acquired in the use of test instruments to trace circuits.

LEARNING TIME

Hours: 90

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instructional Manual for Basic Electricity-Electronics, P59 (text). Electronics Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. General shop practices
   a. tool familiarization and safety
   b. layout and construction
   c. soldering practice
   d. electronic instrument familiarization: ohmmeter
   e. familiarization of components (resistors and capacitors)
   f. wiring and continuity checking procedure
2. Basic electronic instruments
   a. electronic instrument familiarization: voltmeter (VTVM)
   b. voltage divider construction and schematic introduction

c. voltage measurement (DC)

d. electronic instrument familiarization: volt-ohm-milliammeter (VOM)

e. current measurement (DC)

3. Basic circuit measurements

a. series and parallel circuits

b. Ohm's Law verification

c. power rating (wattage)

d. bridge network analysis (DC)

4. Power transformer installation and demonstration of inductance

5. R-C filter installation and demonstration of capacitance

6. Oscilloscope and AC introduction

7. Diodes and triodes

8. Pentode, beam power, and multi-element tubes

9. Power supplies (rectification)

PRINCIPLES OF ELECTRONICS

DESCRIPTION

Principles of Electronics (EA unit A700) ... establishes a foundation for the learner to achieve skills in the broad field of electronic applications. Circuits and their components are examined, including tubes and solid state. Mathematical problems of electricity are studied, but math skill beyond basic trigonometry is not required.

LEARNING TIME

Hours: 180

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Identify the main sections of a system.
2. Identify the basic symbols used in electronic circuits.
3. Define the meaning of voltage, current, resistance, and power.
4. Calculate the effective voltage of cells in series and parallel.
5. Describe or identify the main parts of a dry or wet cell.
6. Describe or identify the chemical action of a lead-acid battery.
7. Calculate the solution to Ohm's Law problems when E, I, R values are provided.
8. Solve problems related to power dissipation when the values of E, I, R are provided.
9. Describe or identify the types of magnetic fields surrounding a permanent magnet, wire, or coil.
10. Describe or identify the action that takes place when a wire loop passes through a magnetic field.
11. Solve problems related to the expansion of current and voltage ranges when the basic characteristics of the meter are provided.

12. Solve problems related to transformer turns ratio, voltage, and current when values are provided.

13. Solve problems related to inductance and resistance in series in an AC circuit.

14. Define or identify the parts of a capacitor.

15. Solve problems related to the time constant equation when values of R and C are provided.

16. Solve problems related to the connecting of capacitors in series and/or parallel.

17. Solve problems related to connecting capacitors and resistors in series in an AC circuit.

18. Solve problems related to phase shift in an AC circuit when R, C, L values are provided.

19. Solve problems related to resonance when values of and C are provided.

20. Describe or identify the action of a diode, triode, pentode, and power tube.

21. Describe or identify the action of a solid state diode, Zener, and transistor.

22. Draw or identify the circuit for a transistor using a single battery.

23. Draw or identify the circuit for a half ε l full wave rectifier or voltage doubler.

24. Draw, identify, and/or name the power supply filters, using L-C-R.

25. Calculate the percentage of regulation for a power supply when load and no-load voltages are provided.

26. Describe and/or identify the operation and use of a VOM, VTVM.

27. Describe and/or identify the operation and use of an audio generator, R-C bridge.

28. Describe and/or identify the operation and use of an oscilloscope.

Acceptable achievement will depend on successful accomplishment of laboratory exercises and trainer activities and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Electronic Systems

1. what they are and how they work

2. diagrams and symbols

3. electronic components

B. Theory of Electricity
   1. what it is and how it acts
   2. the source
   3. effects

C. Direct Current
   1. Ohm's Law
   2. types of circuits
   3. power and fuses

D. Magnetic Fields and Forces
   1. background
   2. characteristics
   3. magnetic components
   4. introduction to alternating current

E. Measuring Electricity
   1. meter measurement
   2. types of meters

F. Inductance
   1. principles of inductance
   2. transformers
   3. inductive circuits
   4. relationship of AC current to voltage

G. Capacitance
   1. principles of capacitance
   2. characteristics of capacitors
   3. physical influence upon capacitors
   4. loss and malfunctions
   5. combinations
   6. capacitance and Ohm's Law
   7. relationship to current and voltage
   8. capacitor applications

H. Alternating Current Circuits
   1. Ohm's Law
   2. phase angle and tangent functions

3. AC circuits in series
4. qualities of inductors and series resonant circuits
5. AC circuits in parallel
6. types of AC circuits

I. Electron Tubes
1. thermonic emission
2. types of tubes
3. tube ratings
4. elements of tube amplification
5. special purpose tubes

J. Solid State
1. basic concepts
2. types and characteristics of diodes
3. junction transistors
4. basic transistor amplifiers
5. transistor characteristic curves
6. practical applications
7. rating transistors
8. other solid state components

K. Power Supplies
1. what they do
2. elements of power supplies
3. regulation

L. Testing Instruments
1. voltage meters
2. audio test generator
3. R-C bridge
4. oscilloscope

CURRICULUM MATERIALS

Basic Electricity-Electronics, P13T (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Experiments in Basic Electricity-Electronics, P13-OE (EA)

Instruction Manual for Basic Electricity-Electronics, P59 (EA)

Teachers Guide for Basic Electricity-Electronics, P13-2 (EA)

Standard Tests for Basic Electricity-Electronics, P13-9 (EA)

Films: Coronet Instructional Materials, 65 E. South Water Street, Chicago, Illinois 60601

"Electrons and Electronics: An Introduction," 11 minutes, 16mm/color

LABORATORY ACTIVITIES

1. Operate and check a record player system
2. Read color codes of circuit leads
3. Read resistor color code
4. Use "powers of 10" number system
5. Construct and test a voltaic cell
6. Test properties of cells in series and parallel
7. Make voltage meter measurements
8. Measure resistance in DC circuits
9. Reveal magnetic lines of force
10. Examine transformer action
11. Measure capacitance
12. Determine charge (Q) and voltage (E) of a charged capacitor
13. Read and operate an oscilloscope
14. Read characteristics of various circuits
15. Determine characteristics of electron tubes studied
16. Observe rectification wave forms
17. Observe various power supply filters at work

Enrichment exercises using the skill trainer PR100 are also available. Construction activities for each unit are suggested. Heavy emphasis is placed upon use of tools for electrical fabrication. Skill is obtained in the use of test instruments to trace circuits. Theory Manual for Fundamental Circuits, P17-T (EA) can be used for supplemental material to the basic text.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

TRANSISTOR FUNDAMENTALS

DESCRIPTION

Transistor Fundamentals (EA unit A400) ... provides the learner with a concentrated study of diodes, transistors, their general and specific characteristics, and engineering and related data. Theory and theoretical equations are related directly to practical applications and measurements. Note: Part A (see Module Outline) is identical to Part A of "Transistor Applications" (EA unit A703).

LEARNING TIME

Hours: 135

OBJECTIVES

Given appropriate instruction and materials, the student will be able to:

1. Draw or identify the circuit for half and full wave rectifiers.
2. Calculate the series resistor for a Zener when the current limits and voltage of the Zener as well as the source voltage are known.
3. Identify basic characteristics of alloy junction, diffusion, mesa, and epitaxial transistors.
4. Identify a CB, CE, or CC audio amplifier having a single battery and required resistors.
5. Calculate the voltage gain of a CE amplifier when provided with sufficient circuit data.
6. Draw a load line on a family of transistor characteristic curves (V_c vs I_c) and determine maximum power output, Q point for Class A operation, expected operating I_c, I_b, V_c.
7. Define ways of stabilizing the operation of a transistor against temperature change.
8. Calculate the current gain of a CE amplifier.
9. Calculate the power gain of a CE amplifier.
10. Show the effects of transistor temperature on the output of a dynamic transfer curve.
11. Calculate the voltage stability factor of a CE amplifier.

12. Draw equipment arrangement for measuring the voltage gain of a CE amplifier.

Acceptable achievement will depend on successful accomplishment of laboratory exercises and trainer activities and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Transistor Fundamentals

1. introduction to diodes and transistors
   a. the atom and matter
   b. conductors, insulators, semiconductors
   c. crystal formation and types
   d. junctions
2. elements of diodes
   a. junctions
   b. diode characteristics
   c. circuits
   d. rectifiers
   e. power rating
   f. diode types
3. transistor elements
   a. types
   b. methods
   c. classification
4. elements of transistor amplifiers
   a. types
   b. single battery biasing
5. characteristics of CE amplifiers - transistor parameters
   a. CE amplifier model of hybrid parameters
   b. gain formulas
   c. conversion formulas, H, Z, Y parameters
   d. input-output resistance
   e. Z and Y parameter
   f. model comparison

6. CB and CC amplifier characteristics
    a. models - common base, common collector, high frequency
    b. transistor noise
7. transistors and cascade amplifiers analysis
    a. load line
    b. characteristic curves
    c. graphical analysis
    d. operational analysis
8. transistor bias stabilization
    a. the problem
    b. factors
    c. stabilization of various elements

B. (If desired, the student may complete Part B, "Industrial Control Applications," of Transistor Applications, EA unit A703 as the second portion of this module. Alternatives for practical applications of transistors can be found in skill trainer PR400 and/or skill trainer PR40.)

CURRICULUM MATERIALS

Transistor and Industrial Controls, P35T (text). Electronic Aids Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Experimental Manual for Transistor and Industrial Controls, P35-0E (EA)

Instructional Manual for Transistor and Logic Control, P67 (EA)

Instructional Manual for Industrial Motor Controls, P83 (EA)

Teachers Guide for Transistor Fundamentals, P35-2 (EA)

Standard Tests for Transistor and Industrial Controls, P35-9 (EA)

Films: Universal Education and Visual Arts, 100 Universal City Plaza, Universal City, California 91608

"The Transistor," #6855, 18 minutes, 16mm/color

LABORATORY ACTIVITIES

1. Familiarization with diodes and transistors
2. Observe characteristics of
    a. germanium diodes

b. silicone diodes

c. diode waveforms

3. Observe transistor junction characteristics

   a. base-emitter junction

   b. base-collector junction

   c. two-junction semiconductor

4. Analyze amplifier fundamentals

   a. measurement of alpha

   b. common base amplifier characteristics

   c. measurement of beta

   d. common emitter amplifier characteristics

   e. measurement of H_{FC}

   f. characteristic curves on oscilloscope

5. Determine amplifier parameters

   a. for CE amplifiers: 1) current and voltage gain, 2) input and output impedance, and 3) calculations

   b. for CB and CC amplifiers - dynamic characteristics

6. Analyze characteristic curves of transistors

   a. load line calculations

   b. biasing point and linearity

7. Stabilize transistor bias

   a. leakage measurement

   b. stabilization techniques and measurements

   c. stability factors

   d. design of stabilized CE amplifier

Enrichment exercises using the skill trainer PR400 and the skill trainer PR40 provide problems related to the study of solid state characteristics, circuit evaluation, errors in circuit design, and research in circuit description and operation. Emphasis is placed upon student investigation and discovery with a minimum of instruction.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

TRANSISTOR APPLICATIONS

DESCRIPTION

Transistor Applications (EA unit A703) ... provides the learner with a basic understanding of solid state devices. Beginning with solid state physics, the module explores the basic parameters of diodes, transistor amplifiers, relay controls, motor generators, and digital logic. Student discovery is emphasized in laboratory experiments and trainer skill activities. Note: Part A (see Module Outline) is identical to Part A of "Transistor Fundamentals" (EA unit A400).

LEARNING TIME

Hours: 180

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Draw or identify the circuit for half and full wave rectifier.
2. Determine, by calculation, the series resistor for a Zener when the current limits and voltage of the Zener as well as the source voltage are known.
3. Identify some of the characteristics of alloy junction, diffusion, mesa, and epitaxial transistors.
4. Identify a CB, CE, or CC audio amplifier having a single battery and required resistors.
5. Calculate the voltage gain of a CE amplifier when provided with sufficient circuit data.
6. Draw a load line on a family of transistor characteristic curves (V_c vs I_c) and determine maximum power output, Q point for Class A operation, expected operating I_c, I_b, V_c.
7. Define ways to stabilize the operation of a transistor against temperature change.
8. Identify a series or shunt type voltage regulator.
9. Draw or identify a coupling circuit needed to continuously vary the gain of a two-stage amplifier.

10. Draw or identify a phase inverter or phase splitter circuit.
11. Draw or identify a push-pull amplifier circuit.
12. Draw or identify a logic OR, AND, NAND, or NOR circuit.
13. Draw or identify a transistor relay control circuit which can be activated by either heat or light.
14. Explain the effects on a drive motor (of a M-G set) when the generator is increasingly loaded.

Acceptable achievement will depend on successful accomplishment of laboratory exercises and trainer activities and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Transistor Fundamentals
   1. introduction to diodes and transistors
      a. the atom and matter
      b. conductors, insulators, semiconductors
      c. crystal formation and types
      d. junctions
   2. elements of diodes
      a. junctions
      b. diode characteristics
      c. circuits
      d. rectifiers
      e. power rating
      f. diode types
   3. transistor elements
      a. types
      b. methods
      c. classification
   4. elements of transistor amplifiers
      a. types
      b. single battery biasing
   5. characteristics of CE amplifiers - transistor parameters
      a. CE amplifier model of hybrid parameters
      b. gain formulas

c. conversion formulas, H, Z, Y parameters

d. input-output resistance

e. Z and Y parameter

f. model comparison

6. CB and CC amplifier characteristics

a. models - common base, common collector, high frequency

b. transistor noise

7. transistors and cascade amplifiers analysis

a. load line

b. characteristic curves

c. graphical analysis

d. operational analysis

8. transistor bias stabilization

a. the problem

b. factors

c. stabilization of various elements

Note: If the student desires to terminate or to change his direction at this point, he will have completed the basic module "Transistor Fundamentals" (A400)

B. Industrial Control Applications

1. regulators

a. voltage theory

b. types of regulators

2. transistors and gate switching circuits

a. DC to AC inverters

b. DC to DC converters

3. the silicon controlled rectifier (SCR)

a. PNPN characteristics

b. types of SCR

c. applications of the SCR

d. other PNPN devices

4. transistor oscillators

a. types

b. characteristics

5. audio amplifiers
    a. types
    b. coupling methods
    c. preamplifiers
    d. frequency compensation
    e. components
6. power amplifiers
    a. amplifier problems
    b. class A types
    c. class B types
    d. class AB, C types
    e. negative feedback
7 modulation and demodulation
    a. communication systems
    b. amplitude modulation
    c. radio transmitters
    d. AM demodulation
    e. radio receivers
8. semiconductor developments
    a. thermal and light sensors
    b. tunnel diode
    c. unijunction transistors
    d. field effect transistors
    e. varactors
    f. control circuits

CURRICULUM MATERIALS

Transistor and Industrial Controls, P35T (text). Electronic Aids Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Experiments Manual for Transistor and Industrial Controls, P35-OE (EA)

Instructional Manual for Transistors and Logic Control, P67 (EA)

Instructional Manual for Industrial Motor Control, P83 (EA)

Teachers Guide for Transistor Fundamentals, P35-2 (EA)

Standard Tests for Transistor and Industrial Controls, P35-9 (EA)

Films: Universal Education and Visual Arts, 100 Universal City Plaza, Universal City, California 91608

"The Transistor," #6855, 18 minutes, 16mm/color

LABORATORY ACTIVITIES

1. Observe diode symbols, color codes and bias characteristics
2. Observe transistor symbols, classification and bias characteristics
3. Observe characteristics of
   a. germanium diodes
   b. silicone diodes
4. Observe oscilloscope patterns of diode static characteristics
5. Test and observe transistor junction characteristics
6. Compare power supply characteristics
7. Observe temperature effects on transistor amplifier circuits
8. Measure DC current amplification
9. Measure CE amplifier characteristics
10. Observe temperature effects on CE amplifiers
11. Observe various transistor circuit applications
12. Examine industrial motor control operation

Enrichment exercises using the skill trainer PR400 and skill trainer PR40 provide problems related to the study of solid state characteristics, circuit evaluation, errors in circuit design, and research in circuit description and operation. Emphasis is placed upon student investigation and discovery with a minimum of instruction.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

TRANSISTOR AND LOGIC SKILLS

DESCRIPTION

Transistor and Logic Skills (EA unit PR400) ... module provides the student with a number of exercises dealing with solid state characteristics, circuit evaluation, and fabrication and handling practices.

LEARNING TIME

Hours: 40

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instruction Manual for Transistors and Logic, P67 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Power supply
2. Series voltage regulator
3. Diode and transistor characteristics
4. Transistor audio amplifier
5. Wein bridge oscillator
6. Phase splitter
7. Differential amplifier
8. Diode clamping, differentiating, and limiting
9. Multivibrator - one shot
10. Sawtooth generator

11. RF oscillator
12. Coincidence circuit
13. Multivibrator, bistable
14. Lamp drivers
15. Binary counter (four flip-flops)
16. Clock pulse generator
17. Diode or gate
18. Diode and gate
19. Inverters
20. NOR gate
21. NAND gate
22. Binary logic-count
23. Student problem 1
24. Student problem 2
25. Student problem 3

OFFICE MACHINES REPAIR SKILLS

DESCRIPTION

Office Machines Repair Skills ... is a student on-the-job practicum. Hands-on experience is provided on a number of business machines such as typewriters, calculators, duplicating equipment, and cash registers.

LEARNING TIME

Module hours will vary

OBJECTIVES

Given the local availability of office machines for hands-on applications, the student will be able to:

1. Perform routine cleaning and maintenance procedures.
2. Check for proper operation and determine source of malfunctions.
3. Perform normal field repairs involving adjustments and parts replacements.

CURRICULUM MATERIALS

Manufacturer's user and maintenance manuals

LABORATORY ACTIVITIES

Under the supervision of a practicing office machines repairman, the student will assist in the following services. Machines may include not only standard office machines but also audio-visual hardware if such machines are serviced locally and arrangements can be made with the service agency to supervise student work.

1. Cleaning
2. Routine maintenance including lubrication
3. Check for normal operation
4. Replacement of defective parts
5. Adjustments
6. Troubleshooting

FUNDAMENTALS OF AM RECEIVERS

DESCRIPTION

Fundamentals of AM Receivers (EA unit A504) ... acquaints the student with the practical application of electronic theory in the form of receivers found in radios and television sets - the superheterodyne. A foundation in basic electronics including audio amplifiers, power supplies and transducers is required. All the circuits studied are solid state. The module is designed to take the student from an explanation of the general receiver system to a detailed study which includes experiments in each of the specific stages of the superheterodyne. Combining, matching, and aligning the individual stages is covered as well as performance characteristics of an audio amplifier circuit. Servicing the receiver is described.

LEARNING TIME

Hours: 135

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Identify the four component parts of a system and select the order in which the parts must be arranged in a functioning system.
2. Select the proper pieces from a given list of test equipment to evaluate receiver operation.
3. Identify the characteristics of a tuned RF amplifier circuit.
4. Select from a schematic diagram of a converter circuit those components which affect the oscillator's operation frequency.
5. Calculate the static bias voltages and static value of collector current in a converter circuit and select the correct answer from a given list of voltages and currents.
6. Select the various regions of operation on a set of static characteristic curves for a germanium diode.
7. Identify the criterion for capacitor size selection in the AVC filter network.
8. Identify the order in which the stages in an IF strip are adjusted during the alignment procedure.

9. Identify the order in which the various components of the oscillator section of an autodyne converter are adjusted during the oscillator alignment procedure.

10. Distinguish between the definitions of the terms sensitivity and selectivity.

11. Select the order in which the distortion measuring apparatus is set up when making a distortion measurement in an audio amplifier circuit.

12. Identify the advantages or disadvantages of the circuit disturbance method of troubleshooting.

13. Identify the advantages or disadvantages of the signal injection method of troubleshooting.

14. Identify the cause of receiver stage failure when given a schematic diagram of the stage in question and a list of possible faults.

15. Select the proper sequential steps when diagnosing the cause of an electronic equipment malfunction.

16. Select the best troubleshooting approach for a given piece of electronic equipment.

17. Indicate when the circuit disturbance method is not recommended because of the danger of electrical shock.

18. Select the proper sequence of testing when using the signal-injection method of analyzing an equipment malfunction.

19. Select the proper test equipment for diagnosing a possible malfunction in an IF stage.

20. Select the most logical troubleshooting method when given a list of available test equipment and equipment symptoms.

Acceptable achievement will be determined by successful accomplishment of the laboratory experiments and skill training tasks and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. AM Superheterodyne Parts and Operation

1. concept of receiver systems

2. stages of AM receiver

a. RF amplifier

b. mixer

1) RF oscillator

2) converter operation - the mixer

c. IF amplifier

1) bandwidth measurement

2) stage gain

d. detectors and demodulation

1) diode detector characteristics

2) modulated wave detection

3) RF by-pass capacitor effects

4) automatic volume control

3. combining, matching, aligning receiver stages

a. IF alignment

b. local oscillator alignment

c. mixer alignment

d. tuning indicator

e. receiver selectivity

f. receiver sensitivity

4. performance characteristics of audio circuits

a. measuring peak output power

b. optimum input voltage

c. measuring distortion

B. AM Receiver Servicing

1. introduction to troubleshooting

2. methods of troubleshooting

a. circuit disturbance

b. signal injection

c. receiver stage faults

CURRICULUM MATERIALS

Electronic Communication Systems (text), George Kennedy. McGraw-Hill, Inc., 330 West 42nd Street, New York, NY 10036

Experiments in Principles of AM Receiver Systems, P38E. Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Principles of AM Receiver Systems, P38-2 (EA)

Standard Tests for Principles of AM Receiver Systems, P38-9 (EA)

Instruction Manual for AM Receiver Skill Trainer PR504 (EA)

LABORATORY ACTIVITIES

1. Operate test equipment in conjunction with radio receiver
2. Demonstrate functions of RF amplifier
3. Test and align RF oscillator
4. Demonstrate mixer functions
5. Measure IF bandwidth
6. Measure IF gain
7. Demonstrate characteristics of detectors and demodulation
8. Align IF stage of superheterodyne receiver
9. Align local oscillator
10. Align mixer with local stations
11. Measure selectivity of receiver
12. Measure undistorted peak power output of receiver audio circuit
13. Measure modulated input power voltage
14. Conduct distortion measurements of receiver audio circuit
15. Demonstrate methods of troubleshooting

Enrichment exercises are provided with the skill trainer PR504. Students practice hands-on skills which are expected of an electronics technician. After assembling each stage of the trainer, the students align and check the receiver component. This procedure develops analytical troubleshooting techniques through analysis of circuitry.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

AM RECEIVER SKILLS

DESCRIPTION

AM Receiver Skills (EA unit PR504) ... provides hands-on skill with an AM receiver component and helps develop troubleshooting techniques through analysis of circuitry. Principles of antenna systems are included using a related unit (A1003).

LEARNING TIME

Hours: 45

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instruction Manual for AM Receiver Skill Trainer, PR504, P38-7 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Tools, components, and techniques
   a. basic tools
   b. safety
   c. PC boards
   d. components
   e. assembly techniques
   f. repair procedures
2. IF output, audio detector
   a. assembly and soldering of components for IF output and audio detector stages
   b. performance characteristics

c. test, circuit evaluation, troubleshooting

3. First IF amplifier stage
   a. installation of components for first IF stage
   b. alignment of first IF stage
   c. performance characteristics
   d. test, circuit evaluation, troubleshooting
4. Automatic volume control (AVC)
   a. installation of AVC components
   b. performance characteristics
   c. test, circuit evaluation, troubleshooting
5. Tuning indicator
   a. installation of indicator components
   b. performance characteristics
   c. test, circuit evaluation, troubleshooting
6. Oscillator
   a. installation of oscillator stage components
   b. performance characteristics
   c. alignment of oscillator
   d. test, circuit evaluation, troubleshooting
7. RF amplifier and front-end tuning
   a. installation of components
   b. performance characteristics
   c. alignment
   d. test, circuit evaluation, troubleshooting
8. Servicing and troubleshooting
   a. demonstration of various troubleshooting and alignment techniques

FUNDAMENTALS OF FM RECEIVERS

DESCRIPTION

Fundamentals of FM Receivers (EA unit A506) ... acquaints the student with the type of radio circuits found in modern high-fidelity sound systems, the FM superheterodyne receiver. A basic knowledge of transistor fundamentals and applications including audio amplifiers, power supplies, and transducers is required. The module begins with an explanation of monophonic and stereophonic receiver systems as well as related test equipment. Each of the following units deals with a different stage of the FM receiver and contains experiments which demonstrate principles, alignment, and performance testing. The final unit covers troubleshooting.

LEARNING TIME

Hours: 135

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Identify the four component parts of a system and select the order in which the parts must be arranged in a functioning system.
2. Select the proper pieces of equipment from a given list of test equipment to evaluate receiver operation.
3. Select the order in which the discriminator transformer is aligned, using a VTVM and an RF signal generator.
4. Select the advantages of using the sweep-marker generator method of discriminator alignment.
5. Select the order in which the stages in the IF strip are adjusted during the IF alignment procedure.
6. Select the order in which the front end is aligned during the oscillator and RF alignment procedure.
7. Select the order in which the various sections of the multiplexer decoder are aligned.
8. Select the advantages of the log periodic V receiving antenna.

9. Select the various signal components present in the composite stereo signal when the amplitude and phase of the L and R input signals are given.

10. Select the reason for using a preemphasis network in an FM transmitter and a deemphasis network in an FM receiver.

11. Select the correct method for phasing loudspeakers.

12. Select the order in which the distortion measuring apparatus is set up when making a distortion measurement in an audio amplifier circuit.

13. Select the advantages and disadvantages of the signal injection - signal tracing method of troubleshooting.

14. Select the probable cause of receiver stage failure when given a schematic diagram of the stage in question and a list of possible stage faults.

Acceptable achievement will be determined by successful accomplishment of the laboratory activities and skill training exercises and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. FM Superheterodyne Parts and Operation
   1. characteristics of FM receiver systems
      a. fundamentals of system
      b. system test equipment
   2. frequency modulation IF amplifiers
      a. differential amplifier
      b. measuring IF bandwidth
   3. limiters and FM detectors
      a. limiters and discriminators
      b. discriminator alignment with sweep-marker generator
   4. frequency modulated receiver stages
      a. IF alignment
      b. oscillator - mixer alignment
      c. receiver selectivity
      d. tuning indicator
      e. FM antenna variations

5. stereo signal demodulation
    a. incoming signal
    b. methods for demodulating FM stereo signal
    c. multiplexer alignment
6. audio circuits
    a. deemphasis network
    b. measuring peak output power
    c. measuring harmonic distortion
    d. measuring hum and noise
    e. phasing loudspeakers

B. FM Receiver Servicing
1. introduction to servicing
2. troubleshooting
    a. signal injection
    b. signal tracing
    c. receiver stage faults

CURRICULUM MATERIALS

Electronic Communication Systems (text), George Kennedy. McGraw-Hill, Inc., 330 West 42nd Street, New York, NY 10036 (1970)

Experiments in Principles of FM Receiver Systems, P40E. Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Principles of FM Receiver Systems, P40-2 (EA)

Standard Tests for Principles of FM Receiver Systems, P40-9 (EA)

Instruction Manual for FM Receiver Skill Trainer, P40-7 (EA)

LABORATORY ACTIVITIES

1. Use test equipment to check FM receiver systems
2. Demonstrate characteristics of differential IF amplifier
3. Measure IF bandwidth
4. Demonstrate characteristics of limiters and discriminators
5. Align FM discriminator using a sweep-marker generator
6. Align IF stage of FM receiver

7. Align oscillator and mixer stages of FM receiver
8. Adjust tuning indicator
9. Rig FM antenna - two types
10. Align FM stereo multiplexer
11. Measure peak output power of FM audio amplifier
12. Measure harmonic distortion of FM receiver
13. Measure hum and noise of FM receiver
14. Phase loudspeakers properly for pleasing sound reproduction
15. Demonstrate troubleshooting techniques of signal injection - signal tracing

Enrichment and skill training exercises are provided with the skill trainer PR506. Students practice hands-on skills which are expected of an electronics technician. After assembling each stage of the trainer, the student aligns and checks the receiver component. This procedure develops analytical troubleshooting techniques through analysis of circuitry.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

FM RECEIVER SKILLS

DESCRIPTION

FM Receiver Skills (EA unit PR506) ... provides hands-on skill with FM receiver components and helps develop troubleshooting techniques through analysis of circuitry.

LEARNING TIME

Hours: 45

OBJECTIVES

The objective of this unit is to provide skill training activities for the related concept module(s). Individual objectives will vary from student to student depending upon goals established by the student and teacher. For additional information on probable objectives, see the list of objectives for the concept module which this unit is to supplement.

CURRICULUM MATERIALS

Instruction Manual for FM Receiver Skill Trainer, PR506, P40-7 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

LABORATORY ACTIVITIES

1. Tools, components, and techniques
   a. basic tools
   b. safety
   c. PC boards
   d. assembly techniques
   e. repair procedures
2. De-emphasis network
   a. assembly and soldering of components for de-emphasis network
   b. performance characteristics
   c. test, circuit evaluation, troubleshooting

3. Discriminator stage
    a. installation of components for discriminator
    b. performance characteristics
4. Second IF and limiter stage
    a. installation of components
    b. performance characteristics
    c. alignment
    d. test, circuit evaluation, troubleshooting
5. First IF stage
    a. installation of components
    b. performance characteristics
    c. alignment
    d. test, circuit evaluation, troubleshooting
6. Tuning indicator
    a. installation of components
    b. performance characteristics
    c. test, circuit evaluation, troubleshooting
7. RF and tuning
    a. installation of components
    b. performance characteristics
    c. alignment
    d. test, circuit evaluation, troubleshooting

PRINCIPLES OF TELEVISION

DESCRIPTION

Principles of Television (EA unit PR301) ... introduces the student to the basic circuitry of black and white television receivers. Construction skills, circuit analysis and testing, and troubleshooting techniques are developed. Principles of antenna systems are included.

LEARNING TIME

Hours: 50

OBJECTIVES

The objective of this module is successful construction of a 14T23 television receiver kit.

CURRICULUM MATERIALS

Instruction Manual for Model PR301 Television Related Skill Trainer, (text), Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Fundamentals of Television, Walter H. Buchsbaum. John F. Rider Publishing Co., c/o Hayden Book Co., Inc., 50 Essex Street, Rochelle Park, NJ 07662 (1964)

Basic Television and Television Receiver Servicing, P. B. Zbar, and S. Schildkraut. McGraw-Hill, Inc., 330 West 42nd Street, New York, NY 10036 (1958)

LABORATORY ACTIVITIES

1. Introduction to general construction techniques
2. Identification of parts
3. Main chassis assembly
4. Filament circuit
5. Low-voltage power supply
6. Audio circuitry
7. IF circuitry

8. Video and sync circuitry
9. Vertical oscillator circuitry
10. High-voltage power supply
11. Final assembly
12. Alignment and troubleshooting

LABORATORY MATERIALS

14T23 television receiver kit - Mycom

INTEGRATED CIRCUIT DESIGN

DESCRIPTION

Integrated Circuit Design (EA unit A405) ... familiarizes the student with circuitry design using modern solid-state components. Linear integrated circuits, ceramic filters, and varactor diodes are closely examined. The emphasis is placed upon how to use these integrated circuits in amplifiers, oscillators, filters, power-supply regulators, instruments, analog circuitry, and bandpass amplifiers. Test methods, including measuring the electrical characteristics of ICs, are performed in laboratory exercises. Computer application of ICs in digital and analog circuits is also covered.

LEARNING TIME

Hours: 75

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Draw or identify a circuit using an OP amplifier which can be used as a summer.
2. Draw or identify a circuit using an OP amplifier which can be used as an integrator.
3. Draw or identify an integrated arrangement circuit for a Wein bridge oscillator.
4. Draw or identify an integrated arrangement circuit for a shunt regulator.
5. Draw or identify an integrated arrangement circuit for a phase shift oscillator.
6. Draw or identify an integrated arrangement circuit for a notch filter.
7. Draw or identify an integrated arrangement circuit for a medical EKG amplifier.
8. Draw or identify a circuit which uses a varactor diode in an oscillator circuit.
9. Draw or identify a circuit which uses a transfilter in an IF amplifier circuit.

Acceptable achievement will depend upon successful accomplishment of laboratory activities and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Theory and Operation of Differential Amplifiers
   1. operation
      a. single-input, single-output
      b. double-ended
      c. common-mode
   2. electrical characteristics

B. Theory and Operation of Operational Amplifiers
   1. inverter
   2. constant gain circuit
   3. unity follower
   4. amplifier types
      a. summing
      b. integrating

C. Oscillators and RF Circuit Design

D. Rectifier and Filter Circuit Design

E. Bandpass Amplifier Circuit Design

F. Pulse and Digital Circuit Design

G. Instrumentation Circuits

H. Special IC Components

CURRICULUM MATERIALS

Theory and Experiment Manual for Integrated Circuits, P87 (text). Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Teachers Guide for Integrated Circuits, P87-2 (EA)

Standard Tests for Integrated Circuits, P87-9 (EA)

LABORATORY ACTIVITIES

1. Test electrical characteristics of differential amplifier
2. Test electrical characteristics and applications of operational amplifier

3. Test electrical characteristics of
   a. Wien bridge oscillator
   b. RF transfilter oscillator
   c. phase shift oscillator
   d. Colpitts oscillator
4. Test electrical characteristics of
   a. shunt voltage regulator
   b. series voltage regulator
   c. constant current generator
5. Test electrical characteristics of
   a. notch filter amplifier
   b. tuned bandpass amplifier
   c. low-pass and high-pass active filters
6. Test electrical characteristics of digital circuits
7. Test electrical characteristics of instrumentation circuits
8. Test electrical characteristics of special IC components
   a. varactor diode
   b. varactor AC attenuator and varactor filter circuits
   c. varactor tuned oscillator
   d. transfilter IF amplifier
   e. transfilter harmonic amplifier

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

LOGIC CIRCUIT DESIGN

DESCRIPTION

Logic Circuit Design (EA unit A403) ... familiarizes the student with the special circuits used in digital logic. These are the circuits vital to the functions of the computer. The module covers seventeen solid state logic circuits as well as a basic introduction to binary numbers.

LEARNING TIME

Hours: 75

OBJECTIVES

Given the appropriate instruction and materials, the student will be able to:

1. Draw or identify a circuit for a logic OR circuit, using diodes.
2. Draw or identify a circuit for a logic AND circuit, using diodes.
3. Draw or identify a circuit for a logic NAND circuit, using diodes.
4. Draw or identify a circuit for a logic NOR circuit, using diodes.
5. Draw or identify a circuit for a logic OR circuit, using two transistors.
6. Draw or identify a circuit for a bistable multivibrator.
7. Draw or identify a circuit for a monostable multivibrator.
8. Draw or identify a circuit for a lamp driver.
9. Draw or identify a circuit for a differential amplifier.
10. Draw or identify a circuit for an emitter follower-buffer.

Evaluation of achievement will depend on successful accomplishment of the laboratory exercises and skill training activities and a minimum of 80% success on objective tests.

MODULE OUTLINE

A. Introduction to Transistor Logic Circuits

1. diode OR gate
2. diode AND gate
3. inverter
4. NAND gate, diode-transistor logic (DTL)
5. NOR gate (DTL)
6. transistor NAND gate (TTL)
7. transistor NOR gate (TTL)
8. bistable multivibrator - static operation
9. bistable multivibrator - dynamic operation
10. monostable multivibrator
11. astable multivibrator - clock
12. Schmitt trigger
13. lamp driver
14. half-adder
15. common-emitter amplifier
16. emitter follower-buffer
17. differential amplifier

CURRICULUM MATERIALS

Theory and Experiment Manual for Logic Circuits, P37 (text). Electronic Aids Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093

Instructional Manual for Transistor and Logic, P67 (EA)

Teachers Guide for Logic Circuits, P37-2 (EA)

Standard Tests for Logic Circuits, P37-9 (EA)

LABORATORY ACTIVITIES

The text, Theory and Experiment Manual for Logic Circuits, provides laboratory procedures and experimental activities.

Enrichment exercises using the skill trainer PR400 relate to the building of specific logic circuits for problem solving.

LABORATORY MATERIALS

See Appendix A for lists of materials and equipment required for laboratory activities and the skill trainer exercises.

CONSUMER ELECTRICITY

DESCRIPTION

Consumer Electricity ... is short on theory and long on practice. The purpose of the module is to introduce the student to the principles of electricity in a painless manner which has immediate value for the consumer - hi-fi nut, rock freak, wheel jockey, kitchen mechanic, shutterbug. The student is given a choice to pursue a project or projects in an area which holds personal interest. The instructor guides the student in the activities and interjects only the theory which is relative to the project. Sufficient reference materials of a do-it-yourself nature are supplied to provide direction and incentive for further study.

LEARNING TIME

Hours: 45

OBJECTIVES

Depending on the choice of projects, the student will be able to:

1. Read a simple schematic diagram of a hi-fi amplifier.
2. Describe manufacturer's specifications for hi-fi equipment and their meaning.
3. Describe magnetic production of sound.
4. Define principles common to all magnets.
5. Describe the principles of synchronous motors.
6. Describe the principles of multiplex tuners.
7. Describe the principle of magnetic recording.
8. Connect the various components of a hi-fi system.
9. Define the unit of electrical power.
10. Describe the effect that increasing or decreasing resistance in a circuit has on the current flowing in that circuit.
11. Describe what happens when any part of the series circuit is broken.
12. Describe the effect that an inductor has on a change in current flow.
13. List the factors in the physical construction of a coil that will affect its inductance.

14. Identify and draw common electrical symbols.

15. Measure wire size using both a wire gauge and a micrometer.

16. Select a voltmeter or combination VTVM and measure the amount of voltage in selected points of an AC/DC electrical system.

17. Select the proper instrument to measure resistance and to check for continuity of the circuit being investigated.

18. Select the proper instrument to measure the amount of current in selected points of electrical systems.

19. Use the oscilloscope to measure various unknown voltages and frequencies.

20. Select and properly use tools for repairing home appliances.

21. Describe the accepted theory of direct current flow and define its unit of measurement.

22. Describe the operation of a lead-acid storage battery.

23. Describe the operation of the automobile alternator and generator.

24. Adjust the proper dwell setting of an automobile ignition system.

25. Describe how light is converted into electrical energy.

26. Describe switching devices - point contacts, mercury switches, relays.

Acceptable achievement will be determined by successful accomplishment of selected projects and a minimum of 80% success on objective and written tests. Only objectives pertaining to the student's selected projects need be accomplished.

MODULE OUTLINE

A. Hi-Fi Equipment
   1. amplifier
   2. speakers
   3. turntable - changer
   4. tuner
   5. tape recorder

B. Electric Guitar Amplifier Repairs

C. Small Appliance Repairs
   1. appliance construction and operation
   2. line cords, plugs, and attachments
   3. heating elements and thermostats

4. small electric motors
5. appliance servicing as a business

D. Automotive Electrical Servicing
1. fundamentals of automotive electricity
2. storage batteries
3. charging systems
4. starting systems
5. ignition systems
6. lighting and electrical accessories
7. building simple test equipment

E. Servicing Automobile Stereo
1. principles of automobile stereo
2. FM multiplex
3. tape cartridge systems

F. Electronics in Photography
1. fundamentals of camera electronics
2. electronic shutters
3. light measurement
4. electronic flash
5. timers
6. sound recording for movies
7. sound synchronizing for movies

CURRICULUM MATERIALS

There is no text specified for the module; however, enough reference books should be available for the number of students working on particular projects. Those listed are essentially of the do-it-yourself nature. The following books can be ordered from Howard W. Sams & Co., Inc., The Bobbs-Merrill Co., Inc., 4300 West 62nd Street, Indianapolis, Indiana 46268

ABC's of Hi-Fi and Stereo, Hans Fantel, No. 20539

Hi-Fi Stereo Handbook, 4th edition, Len Buckwalter, No. 20918

1-2-3-4 Servicing Automobile Stereo, Forest H. Belt, No. 20737

Automotive Electronics, Rudolf F. Graf and George J. Whalen, No. 20856

Automotive Test Equipment You Can Build, A. Edward Evenson, No. 20926

ABC's of Electrical Soldering, Louis Dezettel, No. 20627

Electric Guitar Amplifier Handbook, 3rd edition, Jack Darr, No. 20848

Electronics in Photography, Byron G. Wels, No. 20672

How to Repair Small Appliances, Jack Darr, Volume I No. 20041, Volume II No. 20524

Projects in Basic Magnetism, John Potter Shields, No. 20556

101 Questions and Answers About Electricity, Leo G. Sands, No. 20806

LABORATORY ACTIVITIES

1. Assemble and test components of hi-fi system
2. Build a speaker crossover network
3. Align and service magnetic tape heads
4. Test turntable for constant speeds
5. Repair defective appliances brought from home
6. Adjust dwell of auto ignition
7. Replace points and condensor of car distributor
8. Test electronic ignition systems
9. Replace defective auto lights and turn signals components
10. Build automobile test equipment
11. Remove and test FM multiplex from auto stereo
12. Clean and service auto tape cartridge mechanism
13. Test and repair electronic flash unit
14. Conduct experiments in basic magnetism

LABORATORY MATERIALS

oscilloscope

turntable strobe disc

head alignment test tape

shop tools for appliance repair

automotive dwell meter

automotive solid state engine analyzer

standard electrical shop tools

SUGGESTED FACILITIES LAYOUTS

The facilities descriptions and layout sketches following are intended only as guides. Any number of alternative facility plans could work equally well. For some schools, facilities for this program may already exist. In such cases, the following material may offer the instructor and administration some suggestions for making the facility more effective through minor alterations.

For other schools starting up a new program, it may be necessary to remodel existing facilities. In such cases, it should not be expected that the remodeled facilities will offer every advantage that can be achieved with new facilities.

Even if new facilities are to be provided, a school may be unable to support a complete laboratory either because of enrollment, space, staff, or financial limitations. In such cases, decisions must be made regarding minimum program essentials and then facilities designed to fit.

Whether new or remodeled, facilities may serve multiple or joint functions. Thus business and graphics production areas may be combined; art and graphics study areas could be shared; welding can be done in an auto shop; small engine and automotive shops can be combined; computer and business programs may share spaces; the various health and cosmetology programs can share a common suite; the electronics laboratory could be combined with a physical science laboratory.

Such combinations have served elsewhere to strengthen both programs. Students see the direct relationship of what they are doing with careers in another field, and faculty find professional stimulation and mutual support in working with colleagues in what have often been artificially separated disciplines.

ELECTRONICS/ELECTRICITY LABORATORY

The electronics laboratory will house vocational courses in basic electronic theory and practice that will provide basic entry level skills in the radio, TV, small appliance repair, and electronics career areas.

The total area of approximately 1400 square feet (SF) should be subdivided into a general laboratory area, project storage (250 SF), and equipment storage (150 SF) - see functional zone sketch.

The project and equipment storage areas must provide secure storage. There should be adjustable shelving, 18" deep from floor to ceiling on all available wall space.

There should be two wood-top electronics work benches on the walls at the ends of benches. Students will stand when working at these benches. Benches should be 24" deep and should have closed storage underneath.

The general laboratory area should have 110 and 220 volt electrical outlets on 8' centers on all walls and in the center of the room. An under floor grid system with relocatable outlet boxes is acceptable for floor level service. There should be two master cut-off switches controlling all receptacles. One master switch should be located near the corridor door and one near the door leading to the teacher's office.

The general laboratory area should have a chalkboard, tack board, and sink with hot and cold water.

A lead-in from an outside television antenna should be provided on one work bench wall.

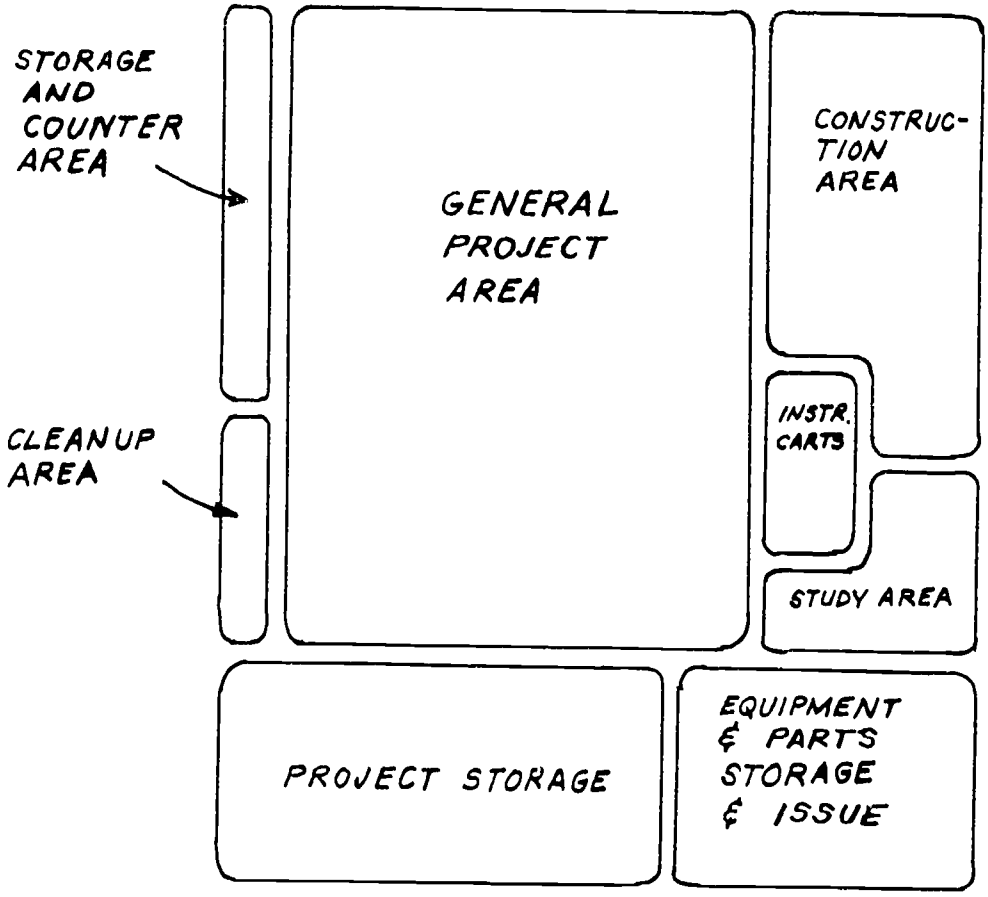
Illumination should provide a minimum of 50 foot candles at desk-top height.

The laboratory should be capable of darkening for the use of visual aids.

In the building that houses the electronics laboratory there should be provision for access to the roof where antennas will be installed for TV and radio reception which will service the electronics laboratory. Antennas will be required for the equipment used. Students will install and service antennas.

The floor should have an insulation barrier over concrete to prevent grounding.

SUGGESTED ELECTRICITY/ELECTRONICS LABORATORY FUNCTIONAL ZONES



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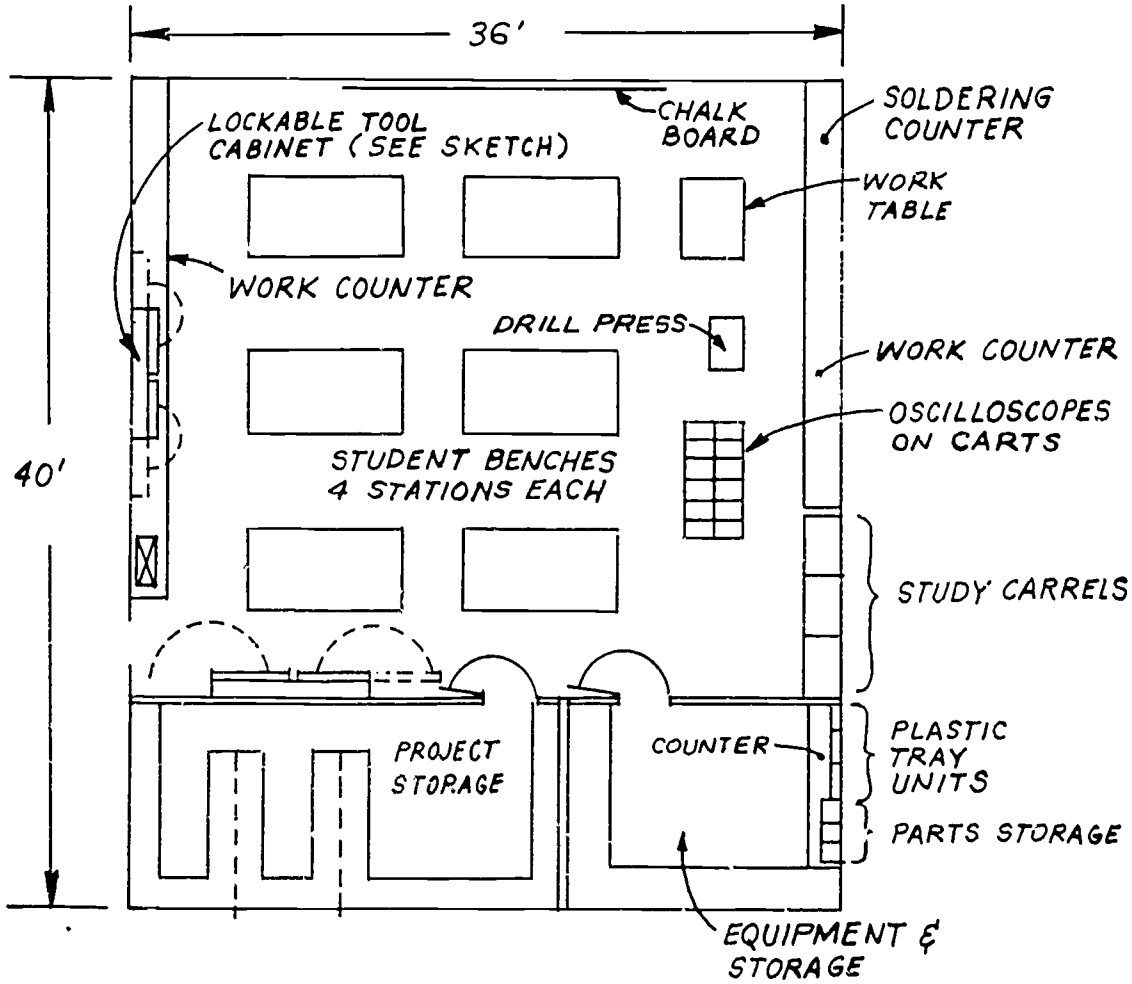
SUGGESTED ELECTRICITY/ELECTRONICS LABORATORY

SCALE 1/8" = 1' ~ 40' X 36'



NOTE: BENCH SIZE MAY BE CUT FROM 8' X 48" TO 8' X 39" TO GAIN ADDITIONAL FLOOR SPACE IF DESIRED.

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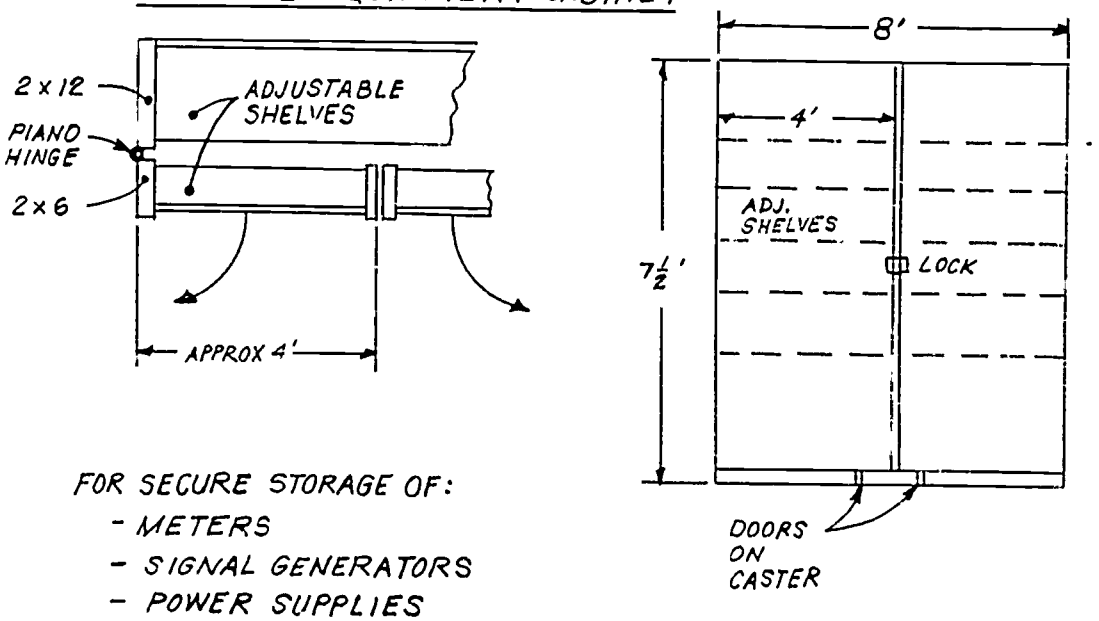
SUGGESTED CABINET DETAIL
ELECTRICITY/ELECTRONICS LABORATORY

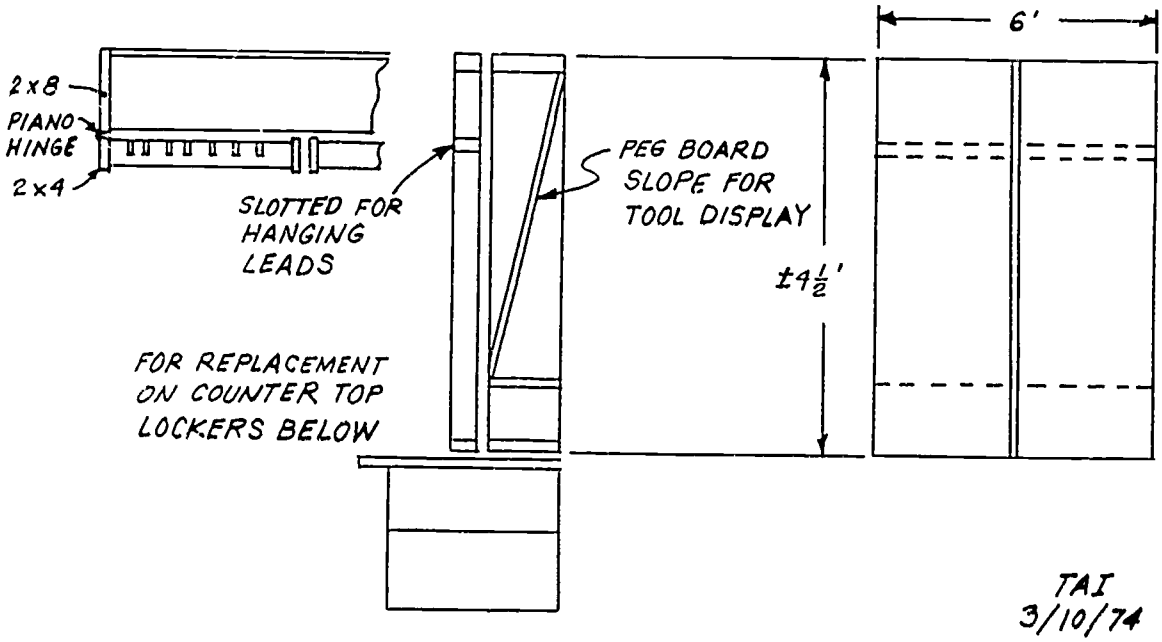
LOCKABLE EQUIPMENT CABINET



FOR SECURE STORAGE OF:

- METERS
- SIGNAL GENERATORS
- POWER SUPPLIES
- SIMILAR EQUIP.

LOCKABLE TOOL CABINET



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APPENDIX A

Each of the modules in this career cluster is built around an integrated learning system developed by Electronic Aids, Inc. (EA), c/o Mycom Media Corporation, 2175 Greenspring Drive, Timonium, Maryland 21093. Texts, manuals, equipment, and supplies are available as total packages, appropriate to each module. These are listed below.

Initial equipment and supplies come with the initial instructional package. Replacement lists are to be found in the teacher's guide for the module.

Units	Number per Laboratory
Concepts of Electricity Instructional System Package includes: 1 trainer with accessories 1 teachers guide (P92-2) 2 student manuals (P92) and 2 standard tests (P92-9), #A1000 (Electronic Aids)	12
Exploratory Electronics Instructional System Package includes: 1 trainer with accessories 1 teachers manual 2 student manuals (P96) and standard tests, #A1100 (Electronic Aids)	12
Basic Wiring Skill Trainer, Wiring Practice Frame Package includes: 1 teachers guide 2 student manuals, #PR50 with PR51 (Electronic Aids)	12
Nerve Finder Package includes: probes, straps, electrodes, electrode solution, and instructions, #A201 (Electronic Aids)	1
Markamatic Student Response Board #EA 30 (Electronic Aids)	12
Markamatic Student-Teacher Response Cards Set includes: 2000 (RC101) student response cards and 200 (TK200) teacher confidential cards (Electronic Aids)	1

Units	Number per Laboratory
Basic Electricity Instructional System Has all necessary components, jumpers, and accessories. Unit is complete with: 1 teachers guide (P91-2) 2 standard tests (P91-9) 2 theory texts (P52T) 2 experiment manuals (P91) 2 student workbooks (P91-9), #A500 (Electronic Aids)	6
Lighting and Alarm Systems Trainer Unit is complete with all accessories and 2 student manuals (P56), #PR55 (Electronic Aids)	2
Basic Electricity/Electronics Instructional System Package includes: 9 modular circuit units all accessories, components, jumper wire, etc. 2 theory texts (P13T) 2 manuals (P130E) 1 teachers guide (P13-2) 2 standard tests (P13-9), #A700CK (Electronic Aids)	6
Basic Electricity/Electronics Construction Skills Package includes: complete reusable unit with case all tubes, components, and manuals, #PR100 (Electronic Aids)	12
Transistor and Industrial Controls Instructional System Unit includes 4 modules, motor generator board, several components, jumpers, and accessories. Unit is complete with: 2 EA text books (P35T) 2 text books (P36T) 2 manuals (P35-0E) 1 teachers guide (P35-2) and tests, #A703 (Electronic Aids)	6
6-Transistor Portable Radio Kit Unit comes complete with instructions and accessories, #IPK67 (Electronic Aids)	12

Unit	Number per Laboratory
Transistor Circuits Instructional System Package includes: 9 modular circuits 33 plug-in components connecting jumpers, alignment tool and adapters 1 teachers guide (P36-2) 2 standard tests (P36-9) 2 theory texts (P36-T) 2 student manuals (P36-E), #A401 (Electronic Aids)	5
Transistor and Logic Skills Trainer Unit is reusable and comes in plastic box with all accessories and 2 student lab manuals (P67), #PR400 (Electronic Aids)	10
Basic Logic Circuits Instructional System Package includes: all plug-in components and accessories 2 plastic modules 2 student manuals (P37), #A403 SK2 (Electronic Aids)	5
Integrated Circuits Instructional System Unit comes in metal box complete with accessories, jumpers 2 student manuals (P87) 1 teachers guide and tests, #A405 (Electronic Aids)	5
Principles of AM Receivers Instructional System Package includes: 3 plastic modules all plug-in components and accessories jumper cables 2 student manuals (P38E) 2 student tests (P38-9) 1 teachers guide (P38-2), #A504 SK1 (Electronic Aids)	5
AM Receiver Skills Trainer Unit is complete with all components and 2 student manuals (P38-7), #PR504 (Electronic Aids)	5

Unit	Number per Laboratory
Principles of FM Receiver Systems Instructional System Package includes: 3 modules 1 baffle box speaker jumpers, components, accessories 1 teachers guide (P40-2) 2 standard tests (P40-9) 2 student manuals (P40-E), #A506 SK1 (Electronic Aids)	5
FM Receiver Skills Trainer Trainer is complete with all components and 2 student manuals (P40-7), #PR506 (Electronic Aids)	5
UHF Antenna Instructional System Package is complete with 4 modules, all jumpers, and accessories 2 student manuals (P20T) and (P20E), #A1003 (Electronic Aids)	1
Television Receiver Trainer Trainer is complete with all accessories and components 2 student manuals (P64), #PR301 (Electronic Aids)	5
Industrial Control Systems Instructional System Package is complete with steel case and 21 moducards, all components, jumpers, and accessories 2 student manuals (P93) 1 teachers guide (P93-2) 2 standard tests (P93-9), #A2000 (Electronic Aids)	4
Motor Construction Skill Trainer Unit is complete with 1/3 HP, 1745 RPM, 120/220 VAC, 50/60 HZ, motor, and accessories 2 student manuals (P82), #PR20A (Electronic Aids)	5
Motor Control Skill Trainer Package is complete with control panel (PR40A) industrial SCR controller 1/6 HP DC motor (PR40B) 3-2 HP motor with electrical brake and motor board cart	1

Unit	Number per Laboratory
10 student manuals (P83), #PR40 (Electronic Aids)	
Fluid Control Fundamentals Instructional System Unit is complete with steel case 12 moducards, all connectors 2 student manuals (P86) 1 teachers manual (P86-2) 2 tests (P86-9), #A1500A (Electronic Aids)	1
Compressor for A1500A Fluid Control Fundamentals Unit is complete with tank, valves, pressure gauges, and (A1500AH) connector hose 115/230 volt, 50/60 HZ motor 100 PSI safety valve 60-75 PSI automatic pressure control #EA-BLCT with A1500AH (Electronic Aids)	1

In addition to the materials supplied in the instructional packages, some basic electricity/electronic tools and instruments should be included as basic shop equipment. These should include the following units:

Impedance. bridge, wheatstone bridge, hay bridge, maxwell bridge, and owens bridge, overall error less than 3% on all ranges, with metal carrying case and headphone, battery operated, #AM200, #67927 (Brodhead Garrett)	1
Hardware cabinet, gray, steel, 36" wide x 12" deep x 87" high. contains 16 bins, one 18-drawer unit and 16 box drawers, has double doors with lock, #T40 (Brodhead Garrett)	2
Digital frequency counter, DC to 32 MHZ, 1 second gate, 10 M second gate, 1 M second gate plus, minus 1 count, plus/minus 1 time base stability, 115 volts, 50/60 HZ, wired, Weston #1250 (Allied)	1

Unit	Number per Laboratory
Transistor-diode, curve tracer, diode, rectifier, signal and power transistor tester to adapt to an oscilloscope for displaying DC characteristics, PIV 5 ranges - 1/10/50/100/200 V/Div., wired, EICO model #443, #166829 (Brodhead Garrett)	1
Solid state sine/square wave generator, 20 HZ to 2 MHZ sine, 20 HZ to 200 KHZ square, 0-10 V peak to high impedance, 105/132 volts, 50/60 HZ, wired, EICO #369, #167324 (Brodhead Garrett)	12
Post marker/sweep generator, marker frequencies crystal controlled, 3.08, 3.58, 4.08, and 45.00, 45.75, 47.25, 67.25, and 193.25 MHZ plus/minus, .005% 120 volts, 50/60 HZ AC, wired, #IGW-57A (Heath)	1
Solid state RF signal generator, 100 KHZ to 54 MHZ, RF coarse attenuation, RF fine attenuation, internal modulation. Approximately 400 HZ from 0 to 100% 105/132 volts, 50/60 HZ AC, wired, EICO #330, #167324 (Brodhead Garrett)	12
Power supply, transistorized, 30V, 117V, 50/60 CY, adj. voltage with meter and test leads (EICO 1020 or equal), #26-395 or #25-538 (Paxton)	12
Television analyst, eight VHF RF channels (UHF channels 14 to 82), 20 to 45 MHZ IF, audio video, sync and color adjustment patterns, 120 volts, 50/60 HZ, wired, B and K model #1077B (Brodhead Garrett)	1
Analyzer, audio, AC VTVM, wattmeter, and intermodulation analyzer, 10 HZ to 50 KHZ, plus/minus 1 DB, 4, 8, 16, or 600 ohm internal load, 120 volts, 50/60 HZ, wired, #IM-48 (Heath)	1
Automotive solid state engine, analyzer, check voltage, engine RPM, dwell angle, amps, ohms, spark output, diode/leakage, EICO #888 (Brodhead Garrett)	1

Unit	Number per Laboratory
Grid dip meter, covers AM and FM bands, low and high mobile radio bands, citizens band, and all ham bands through VHF, wired, EICO #710, #167083 (Brodhead Garrett)	1
Meter, BOM, 50 UA movement, circuit protected push-button circuit breaker, 0-10 ampers DC, 0-5000 F, AC/DC 20 KOHM/VDC sensitivity, 5 KOHM/VAC, Simpson goof-proof #260-6 P, #168064 (Brodhead Garrett)	12
Meter, VOM, solid state, 9 range DC and AC 0-1, 500 volts AC/DC 7 range ohmmeter XI to XI meg. 11 range AC/DC ampmeter 0-1.5 MA. battery or 120/240 volts, 50/60 HZ AC, wired, #IMW-25 (Heath)	1
Oscilloscope, 5" screen, built-in 1 volt P-P reference source, 10 HZ - 500 KHZ 120/240 volts 50/60 HZ AC, wired, #10W-102 (Heath)	12
Oscilloscope, complete dual-trace capability, separate signal display in CH 1 or 2 modes, 18 calibrated rates for triggering, switch-selected AC or DC coupling, 120/240 volts, 50/60 HZ AC, wired, #EU-70A (Heath)	1
Probes, oscilloscope, high frequency compensated, 10 meg. DC-30 MHZ 500 V AC or DC max, PKW-101 (Heath)	12
Probe, oscilloscope, low capacitance, provides direct or X10 attenuated operation kit, PK-1 (Heath)	2
Probe, oscilloscope, demodulator, 30 V RMS, 500 VDC max, 337-C (Heath)	2
Solid state signal tracer, independent RF and audio inputs, 400 MW output, 200 UA meter movement, 105/132 volts, 50/60, HZ AC, wired, EICO #150, #167240 (Brodhead Garrett)	1

Unit	Number per Laboratory
Component substitutor, resistance-capacitor 12.1 watt resistors, 10-5.6 K ohms 12. 1/2 watt resistors, 10 K-5.6 meg ohms 10,600 V capacitors, 100 MMFD to .5, 5 MFD. Also substitutes selecium and silicon rectifiers, Sencore #RC-146, #167580 (Brodhead Garrett)	1
Electronic switch, signal frequency response, DC-5 MHZ plus 1-1/2 DB-3 DB, 120/240 volts, 50/60 HZ AC, wired, #ID-101 (Heath)	1
Tester, capacitor, actual capacitance and power factor measurements. 110/125 volts, 50/60 HZ AC, wired, Sprague #M-3 (Brodhead Garrett)	1
Tester, crt. tests and rejuvenates crts for opens, shorts, or leakage (cathode ray tube), wired, B and K model #466 (Brodhead Garrett)	1
Tester, integrated circuit, tests 14 and 16 pin dual-in-line devices, static and dynamic logic levels, wired, battery powered, #1 C 590 (Allied)	1
Tube and transistor tester, dynamic conductance, tests domestic and foreign tubes, 5 and 7-pin novistors, 9-pin novars, 12-pin compactrons, 7, 9, and 10-pin miniatures, 5, 6, 7, and 8-pin subminiatures, octals and locatals, wired, EICO #667, #166840 (Brodhead Garrett)	1
Tool Kit, electronic technicians, complete set of electronic tools, contained in a metal box with lock. Approximately 20 tools, model #TK1 (Electronic Aids)	14
Tool Kit, electricians, complete set of electrician tools, contained in a metal box with lock. Approximately 20 tools, model #TK4 (Electronic Aids)	14

Unit	Number per Laboratory
Tool kit, service master, 23-piece set of Xcelite variety of quick-change tools and combinations to speed up assembly and service work, with plastic case. Kit #99 SM, #170416 (Brodhead Garrett)	2
Allen hex type screwdriver set, size 1 1/16" x 4 1/8" 11 pieces, #99 PS-40, #170460 (Brodhead Garrett)	2
Bristol screwdriver set, 11 pieces, size 1 1/16" x 4 1/8" #99 PS-60, #170460 (Brodhead Garrett)	2
Bench, for electronic laboratory, 4-student electronic workbench with lockable storage for 86 polycarbonate electronic subsystems, natural birch, 8'3/4" x 5'3/4" x 31"; top is covered with unburnable colored fiberglass-asbestos (green)	6
Shop assortment of resistors, capacitors, transistors, etc. to be used as needed	